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In this issue



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frontispiece

Fluoridation of drinking water in Washington, D.C., was started June 1952 by the U.S. Army Corps of Engineers at the Dalecarlia Reservoir. (Statements on the fluoridation of public water supplies appear on pp. 511-520.)

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

ARTHUR S. FLEMMING, *Secretary*

PUBLIC HEALTH SERVICE

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Evaluation of the Rapid Plasma Reagin Test in Field Operation

W. G. SIMPSON, M.D., AUSTIN W. MATTHIS, M.D., AD HARRIS, and ELEANOR V. PRICE

THE rapid plasma reagin (RPR) test for syphilis has been described by Portnoy, Garson, and Smith (1) as a method suitable for use in population groups whose rapid movement or concentration presents difficulties in syphilis control. Limited time for testing, diagnosis, and treatment, and difficulty and expense of followup suggest the use of this procedure.

One such mobile group entering the United States annually has been the several hundred thousand braceros, Mexican farmworkers, who pass through the reception centers on the U.S. border. Health examinations performed rapidly and efficiently by the Foreign Quarantine Division of the Public Health Service at the border reception centers have not included routine blood tests for syphilis. Complete serologic screening of all of these migrants has been prohibitive because of the man-hours required for testing and the problems involved in followup, diagnosis, and treatment, as indicated, of positive reactors who had been dispersed to farms before test results were available.

However, previous sample blood tests of these workers have shown the advisability of

serologic testing. In 1951 a small group of 11,850 were blood tested for syphilis, and 12.8 percent were reactive. In 1956 a larger sample, 117,776, was tested, and 8,646, or 7.3 percent, were found to be reactive.

The use of the RPR test makes possible rapid diagnosis and treatment while the workers are at the reception centers. Results may be obtained on individual specimens in 18 minutes and made available to the diagnostician within 40 minutes after the specimen is drawn.

Study Group

The test was first used in a large-scale field operation at the El Centro, Calif., Reception Center between April 16 and June 28, 1957. Under the direction of the originators of the test, a field team from the Venereal Disease Experimental Laboratory, Chapel Hill, N.C., tested 47,579 Mexican agricultural workers. Of this number, 3,913 specimens, or 8.2 percent, were reactive and an additional 685, or 1.4 percent, were weakly reactive. Although weakly reactive test results were recorded, only the reactive test results were referred to the diagnostician. This practice of grouping the weakly reactive with the nonreactive results of the RPR test has been continued in the laboratories of the Mexican border reception centers.

During this survey period, diagnoses of syphilis, by stage, based on physical inspection and examination, blood test, and darkfield microscopy, as indicated, included 31 primary and secondary (25 of which were seronegative), 985 early latent, and 2,712 other stages of syphilis. Of the other reactive specimens, 72 were

Three of the authors are with the Communicable Disease Center, Public Health Service. Dr. Simpson is assistant chief and Mrs. Price is a statistician of the Venereal Disease Branch, Atlanta, Ga., and Mr. Harris is director of the Venereal Disease Research Laboratory at Chamblee, Ga. Dr. Matthis is the health officer of the Imperial County Health Department, El Centro, Calif. (Manuscript received for publication February 2, 1959.)

RPR testing projects have been established in the five border reception centers at El Paso, Hidalgo, and Eagle Pass, Tex., Nogales, Ariz., and El Centro, Calif., by the Division of Foreign Quarantine to screen all braceros on a routine, year-round basis. The RPR test has also been used successfully in demonstration projects in Cook County Jail in Chicago and with migrant groups in North Carolina and Arizona.

diagnosed as pinta. Eight workers had previously received adequate treatment for syphilis and 130 could not be located.

Those workers for whom treatment was indicated received 2.4 million units of benzathine penicillin G as a single 4-cc. intramuscular injection. All but two in the primary and secondary stage were discovered as lesion suspects by the Foreign Quarantine personnel in their routine health examination, demonstrating the effectiveness of this inspection, and were confirmed as darkfield-positive by the special project physician assigned by the Venereal Disease Branch.

Methods

In order to compare the performance of the RPR test to several other blood-testing procedures, a total of 1,672 blood specimens from braceros previously tested by the RPR test at El Centro were shipped to the Venereal Disease Research Laboratory at Chamblee, Ga., where the VDRL slide, Kolmer cardiolipin complement fixation, Hinton flocculation (2), and *Treponema pallidum* complement fixation (3) tests were performed. These tests were

selected for comparison with the RPR test because they represented a slide flocculation, tube flocculation, and a complement fixation test with cardiolipin antigens and a test using treponemal antigen.

To obtain sufficient reactive specimens for a valid comparison of these tests, approximately one-half the sample was drawn from persons reactive to the rapid plasma reagin test, the other half from those who were nonreactive.

Results

In the total group of 47,579 braceros tested, the RPR test was nonreactive in 90.4 percent, weakly reactive in 1.4 percent, and reactive in 8.2 percent. The corresponding percentages for the sample group of 1,672 specimens were 45.8 percent nonreactive, 6.3 percent weakly reactive, and 47.9 percent reactive (table 1). The ratio of weakly reactive to reactive was 1:5.9 in the total group and 1:7.6 in the sample. Among the other four tests performed on the sample, the VDRL slide test obtained the highest percentage of nonreactive results (55.7); and the TPCF test, the lowest (35.5).

A comparison is made in table 2 of the results of the rapid plasma reagin test with corresponding results of the VDRL, Hinton, Kolmer, and TPCF tests in 1,604 specimens giving definite results to all tests. Among 747 specimens nonreactive to the RPR test, almost parallel nonreactive results are seen with the VDRL slide test (99.5 percent), Hinton (99.1 percent), and Kolmer (98.4 percent). The TPCF test shows least agreement, with only 69.2 percent nonreactive. The 103 specimens weakly reactive to the RPR test were 77.7

Table 1. Total sample of 1,672 specimens from El Centro, Calif., by test result

Test	Nonreactive		Weakly reactive		Reactive		Anticomplementary		Not tested	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
RPR.....	766	45.8	105	6.3	801	47.9				
TPCF.....	593	35.5	271	16.2	758	45.3	30	1.8	20	1.2
Kolmer cardiolipin.....	809	48.4	29	1.7	813	48.6	11	.7	10	.6
Hinton flocculation.....	829	49.6	37	2.2	774	46.3			32	1.9
VDRL.....	932	55.7	143	8.6	591	35.3			6	.4

Table 2. Comparison of RPR test with VDRL, Hinton, Kolmer, and TPCF tests in 1,604 specimens from El Centro, Calif., giving definite results to all tests (anticomplementary and not tested excluded)

Result of other tests	VDRL slide		Hinton flocculation		Kolmer cardiolipin		TPCF	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
747 specimens nonreactive to RPR								
Nonreactive.....	743	99.5	740	99.1	735	98.4	517	69.2
Weakly reactive.....	1	.1	1	.1	2	.3	119	15.9
Reactive.....	3	.4	6	.8	10	1.3	111	14.9
103 specimens weakly reactive to RPR								
Nonreactive.....	80	77.7	54	52.4	38	36.9	5	4.9
Weakly reactive.....	16	15.5	11	10.7	14	13.6	16	15.5
Reactive.....	7	6.8	38	36.9	51	49.5	82	79.6
754 specimens reactive to RPR								
Nonreactive.....	93	12.3	33	4.4	25	3.3	64	8.5
Weakly reactive.....	125	16.6	24	3.2	12	1.6	135	17.9
Reactive.....	536	71.1	697	92.4	717	95.1	555	73.6

percent nonreactive to the VDRL, 52.4 percent nonreactive to the Hinton, and 36.9 percent nonreactive to the Kolmer test. Only 4.9 percent of these specimens were nonreactive to the TPCF test.

Of the 754 specimens reactive to the RPR test, the greatest agreement is with the Kolmer test, with 95.1 percent reactive and only 3.3 percent nonreactive; agreement is also close with the Hinton test, in which 92.4 percent of the specimens were reactive and 4.4 percent nonreactive. Oddly enough, the VDRL slide and TPCF tests, at opposite extremes in reactivity in specimens nonreactive and weakly

reactive to the RPR test, have approximately the same reactivity rates, 71.1 and 73.6 percent, respectively among specimens reactive to the RPR. When weakly reactive and reactive results are combined for each of the compared tests, total reactivity ranges from 96.7 percent for the Kolmer to 87.7 percent for the VDRL in the group of 754 specimens reactive to the rapid plasma reagin test.

The actual percentage of agreement between the RPR and the other compared tests in these 1,604 specimens is shown in table 3. Complete agreement is defined as both tests nonreactive, both tests weakly reactive, or both tests reac-

Table 3. Percentage of agreement between RPR and other tests in 1,604 specimens from El Centro, Calif., giving definite results to all tests

Other tests	Complete agreement		Partial agreement		Disagreement	
	Number	Percent	Number	Percent	Number	Percent
Kolmer.....	1,466	91.4	63	3.9	75	4.7
Hinton flocculation.....	1,448	90.3	62	3.8	94	5.9
VDRL slide.....	1,295	80.7	132	8.2	177	11.1
TPCF.....	1,088	67.8	217	13.6	299	18.6

tive. A reactive result to one test and weakly reactive result to the other is considered partial agreement. The RPR was in complete agreement with the Kolmer test in 91.4 percent of the specimens and with the Hinton in 90.3 percent. Complete agreement is lowest when the RPR is compared with the TPCF test, 67.8 percent. Disagreement with the rapid plasma reagin test ranges from 4.7 percent for the Kolmer to 18.6 percent for the TPCF test.

In order to determine the type of specimens in which the majority of discrepancies occurred, the results of the TPCF test are compared with the results of the RPR and VDRL quantitative slide test (fig. 1). The general pattern of this chart—an increase in percentage of specimens reactive to the TPCF test with increasing reactivity of the RPR and VDRL slide tests—is broken by the second bar which represents specimens which were weakly reactive to the RPR and nonreactive to the VDRL test. In this group, 80 percent were reactive to the TPCF test and only 3.8 percent were nonreactive. Among 743 specimens which were

Figure 1. Result of TPCF test compared with results of RPR and VDRL tests.

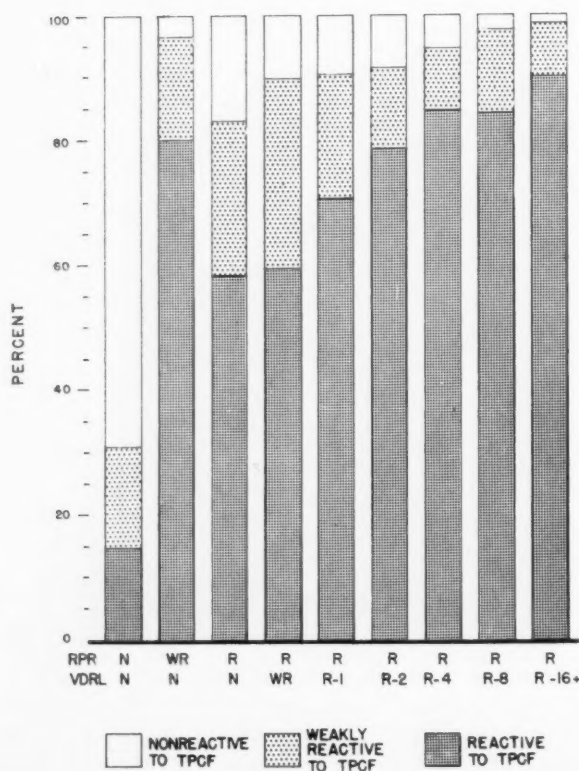
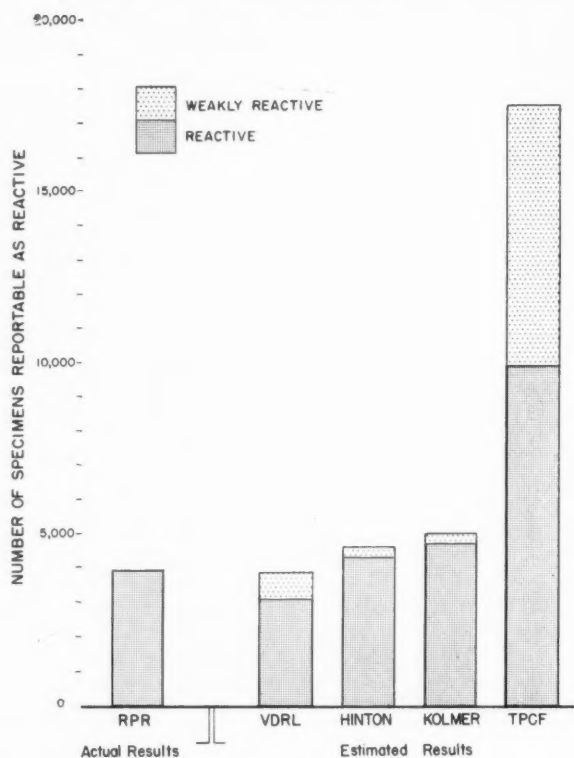


Figure 2. Actual reactivity of RPR test and estimated reactivity of other tests among 47,579 braceros tested in 1957, El Centro, Calif.



nonreactive to both the RPR and VDRL tests, more than 3 out of every 10 specimens showed some reactivity to the TPCF (14.5 percent reactive and 16 percent weakly reactive). Although this latter observation would indicate greater sensitivity of the TPCF test, among specimens reactive to the RPR, the percentage nonreactive to the TPCF ranged from 17.2 percent when the VDRL was nonreactive to 1.3 percent when the VDRL was reactive to 16 or more dils.

On the basis of the results obtained in the sample, estimates have been made of the number of specimens that would have been reportable (reactive or weakly reactive) in the Kolmer, Hinton, VDRL slide, and TPCF tests, had these tests been performed on the total 47,579 specimens. Only the reactive results of the RPR test are reported to the physician at the bracero reception center laboratories, whereas both reactive and weakly reactive results of the other tests are reportable. Therefore, consideration was given to these practices in preparing the estimate for comparison of

these several testing procedures. These estimates are compared with the actual number of specimens that were reactive to the RPR test (fig. 2).

As opposed to the figure of 3,913 specimens (8.2 percent) that were reactive to the RPR test, 3,865, or 8.1 percent, would have been reactive or weakly reactive to the VDRL slide test; 4,547, or 9.6 percent, to the Hinton; 4,948, or 10.4 percent, to the Kolmer; and 17,452, or 36.7 percent, would have been reactive or weakly reactive to the TPCF test. (The TPCF technique employed in this evaluation was found to have a high reactivity and a low specificity in the SERA study (4) and has since been modified by the test's authors.) The actual number of specimens reactive to the RPR test most closely approximates the number of reportable reactions for the VDRL slide test.

Discussion

The group of specimens under consideration was highly selective, being taken entirely from Mexican male laborers with an unknown percentage of associated pinta, and selected on the basis of the result of the RPR test (roughly one-half reactive, one-half nonreactive). The results reported here may differ considerably from results obtained in a random sample of the population. In this series, however, the result of the RPR test agreed closely with the results of the Kolmer cardiolipin and Hinton flocculation tests.

Summary

During the period April 16 through June 28, 1957, a total of 47,579 Mexican agricultural workers were tested with the rapid plasma reagin test at El Centro, Calif. Reactive re-

sults were obtained in 3,913 and weakly reactive results in 685, a total reactivity rate of 9.7 percent.

In this same period a sample consisting of 1,672 specimens from workers tested by the RPR test was subjected to a battery of tests, including the VDRL slide, Kolmer cardiolipin complement fixation, Hinton flocculation, and TPCF, at the Venereal Disease Research Laboratory.

The Kolmer and the Hinton tests were in closest agreement with the RPR test, the percentage of complete or partial agreement being 95.3 and 94.1, respectively. Least agreement was obtained with the TPCF test, 81.4 percent. The TPCF test showed some reactivity in 3 out of every 10 specimens which were nonreactive to both the RPR and VDRL slide tests.

If one of these other tests had been used in place of the RPR at the El Centro reception center, it is estimated on the basis of the sample that reactive or weakly reactive results would have been obtained by the VDRL slide test in 3,865, by the Hinton in 4,547, by the Kolmer in 4,948, and by the TPCF in 17,452 specimens from the Mexican workers tested.

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Current knowledge and thinking about State agency planning for community mental health services are examined.

State Agency Program Planning for Community Mental Health

CHARLES F. MITCHELL, M.A.

IN SPITE of the rapid advance of community mental health services, the dominant theme at national and regional meetings of State mental health personnel is still largely mental hospitals and mental patients. Yet severe mental illness is such a small part of the total picture that it seems important to look at the whole range of mental health needs and services.

The latest available estimates indicate that about 10 percent of the population of the United States have significant mental health problems, but only 0.6 percent are ill enough to require care in a psychiatric hospital (1, 2). The other 90 percent, the so-called normal group, need mental health education and counseling services to help prevent the development of disabling mental illness. In planning programs for community mental health services we have to look at the entire spectrum and visualize all potential needs.

About 10 years ago, in the early stages of community mental health planning, it all seemed pretty simple to us in State mental

health agencies. First, we were supposed to develop further the existing mental health clinics and to start new clinics as rapidly as possible. There was little question as to what kind of clinics they should be. Second, we were supposed to set up an educational program, consisting of talks, workshops, films, and pamphlets, aimed at whatever groups seemed to be interested.

Now we are not quite so glib in discussing or plunging into these activities. We do more systematic and down-to-earth planning, and we use criteria for program selection. But we need to reexamine these criteria frequently and look at the assumptions and principles that underlie them.

Current Assumptions

These are the current assumptions that influence our planning:

★ Two attitudes seem to predominate among those persons who are concerned in some way with community mental health programs. One is the extreme optimism reflected in the idea that "mental health is all," a sort of cultist mental health movement. The other is a pessimistic attitude that "this preventive stuff" is all a nice frill, but "you can't prove that it prevents anything and it is not a real program like some others, and not nearly as important as taking care of the acutely mentally ill."

Mr. Mitchell has been with the Texas State Department of Health for 10 years and director of the division of mental health for 7. The article is based on a talk given at the regional workshop for State-level mental health program personnel held by the Community Services Branch, National Institute of Mental Health, Public Health Service, at Brighton, Utah, April 21-25, 1958.

Somehow we have to find a middle ground and recognize the climate of public opinion in which we have to operate.

★ Community mental health programs in most States are going to be small for a long time, because no large appropriations will be made until we have specific preventive methods that are more definitely proved. Moreover, there are not likely to be pressure groups available, such as the councils for the mentally retarded, to get funds for our programs. We don't have an organization of relatives of the neurotic who are going to work with State legislatures to get funds.

★ The number of professional mental health personnel will not greatly increase in the next 5 to 10 years.

★ No one type of program will do the job, nor is it possible to carry out all of the potentially productive community mental health activities.

★ Mental health associations and other lay groups are already carrying on educational programs, some of them in community mental health. Such programs are likely to increase further in both number and scope in the future.

★ Many nonmental health professional persons and agencies already perform various community mental health functions. They have varying degrees of awareness of their actual and potential roles. These people and agencies can be aided through consultation and organizational measures to do a much more effective and comprehensive job. Some already are seeking such help.

★ Existing mental health clinics are not being fully utilized. For example, the recent study of the Los Angeles Child Guidance Clinic showed that nearly 80 percent of the cases seen in 1 year could have been treated just as well or better by other local agencies or by private practitioners (3). In addition, it seems obvious that clinics can do much more consultative and educational work with other agencies and practitioners and can relate their traditional services more directly and meaningfully to those of other agencies.

★ Psychiatric services in general hospitals are growing rapidly in number, size, and function. It is an open question how well such services are currently integrated into local and

State patterns of community mental health services.

★ Local policymaking and control are essential for long-range, permanent growth of community mental health services, if the services are to endure. State control and operation tend to inhibit local growth and participation. Of course, this assumption is affected by State and local traditions and the geography and economy of a particular State.

★ State agency planning for local mental health services must take into account local experience and the attitudes and methods traditionally used in other civic projects. Hunter has highlighted the importance of local power structures in this connection (4, 5).

★ The nature of the State program for community mental health will be markedly affected by its parent agency and the value systems of the particular professional disciplines on the staffs of the State program and the parent agency.

Principles and Basic Questions

The State agency obviously must accept the dual responsibility of developing further existing patterns of service and of initiating projects which test different combinations of approaches to preventive services in mental health while evaluating the effectiveness of both the old and the new.

Selecting preventive program areas is difficult. We need activities which are tangible, dramatic, convincing, and based directly on need. We cannot continue indefinitely on faith or on the basis of testimonial evidence that we are doing something that justifies our use of the taxpayer's dollar.

Also we are recognizing more clearly that clinics are expensive and that they alone cannot meet all the mental health needs of the community. Clinics provide an essential service, but perhaps should be thought of as a springboard for other activities.

It seems helpful to categorize the kinds of possible activities according to four levels of prevention so that we get some idea of the scatter of our various activities among these levels.

Level 1 prevention consists of building and

maintaining mental health through programs that teach the best current knowledge and the best methods of fostering healthy parent-child relationships and human relationships generally.

Level 2 includes all the activities carried out by the nonmental health professional people in private practice or as staff of health, welfare, and education agencies. The physician, nurse, teacher, social worker, clergyman—all those in a "caretaking" capacity in the community—can do early casefinding and provide counseling and guidance to individuals, particularly children, showing symptoms of emotional disturbance.

In this level, we are inclined to overlook the significance of the clergy. A public opinion study done in Louisville, Ky., a few years ago showed that people turn most frequently to their clergyman when they have problems.

Level 3 prevention consists of services provided in clinics, primarily diagnosis and treatment of moderate emotional disturbances.

Level 4 consists of services in general hospitals for the acutely ill psychiatric patient, as well as rehabilitation of mental hospital patients who have returned to the community.

Probably the major dilemma in program planning is where to begin in the whole spectrum of possible services. Should we try to improve the mental health of the entire population, or concentrate on the 6 percent of the families who have a high incidence of social and emotional disorders?

A promising approach is to focus on populations at risk. Schwartz lists nine groups worthy of concentrated efforts in community mental health (6):

1. Juvenile delinquents. For his purpose Schwartz limits this category to delinquents whose parents have been in trouble with the law.
2. Persons who have attempted suicide.
3. Those in urban areas where the rate of incidence for mental illness is high.
4. Expectant mothers who need help in preventing organic damage to the unborn child and in emotional problems.
5. Children under 3 years of age who are physically and emotionally deprived of mothering (7).
6. Families on relief.

7. Bereaved persons who need help in handling their "grief work," as described by Lindemann (8).

8. The acutely psychiatrically ill. Psychiatrists and other mental health staff can provide emergency services at home to prevent hospitalization. Successful programs of this kind have been carried out in Amsterdam in the Netherlands and in Philadelphia, Pa.

9. Persons who are slated for promotion to positions at a higher level. This group has a high incidence of problems.

Another approach, advocated by Caplan of the Harvard School of Public Health, is to center efforts on the crisis periods in people's lives when they are most amenable to changes in basic attitudes (9).

Certainly we must compromise in considering the direction and the distribution of mental health activities. For example, if we can conduct only two special demonstration projects during a given period, probably it would be a good idea to work with one group in which the risk is not commonly recognized, such as gifted children. The other might focus on a group, such as aged persons in nursing homes, whose actual or potential mental health problems are apparent to most people.

Should we try to provide services to all geographic areas of the State? We might provide educational materials to the entire State; then, in a few areas, set up projects as demonstrations and encourage other communities to emulate those which appeal to them.

Another question is whether to move into communities that do not request services. When there are epidemics or excessive mortality or morbidity rates, public health teams traditionally have moved in without waiting for an invitation. Yet most of us question whether permanent gains in community health are made without local initiative and local assumption of responsibility and leadership. How long do we wait before we approach a community which requests no services but has obvious and critical needs?

Developing Existing Services

In considering existing patterns of services, probably nobody claims that the mental health clinics at present are working at their maximum

potential in community mental health. Perhaps the most important task of the State agencies is to convey a spirit of experimentation and evaluation of diagnostic and treatment functions to the clinics and the psychiatric services of the general hospital.

Perhaps we can, to some extent, motivate clinic directors, boards, and staffs to reexamine traditional procedures, such as the handling of waiting lists, diagnostic procedures, treatment methods, preventing dropouts of patients, followthrough of treated patients with referrals to other agencies, and followup studies of patients already seen.

Another goal might be to encourage existing clinics to devote more staff time to consultation, education, and community organization functions. Perhaps we should insist that new clinics devote a certain portion of staff time to these functions in addition to diagnostic and treatment services.

Clinicians in general are increasingly aware of their potential contribution to and of the value of such activities, but to what extent are they able to perform consultation and education functions? Should we encourage the clinics to serve as a hub for all community mental health activities? Can we expect them to do this without special training for their staffs? And should the State agency provide scholarships for advanced training to help clinic staffs carry out new methods of service to the community? Where can one get such training? Perhaps the State agency should attempt to provide it.

Another question concerns existing services. What are the disadvantages and advantages of written agreements if financial aid is provided to the clinics? Is it sound to use such agreements as a basis for periodic discussions of the clinic's program and function? Few persons would argue that the State agency should not set some standards, particularly for personnel. It is surely appropriate to encourage the clinic to use State agency staff in a consultative capacity, both in basic administration and in various specialized clinic functions.

In a number of States, statewide workshops on a variety of topics or inservice training programs for staffs have been undertaken with considerable success.

The recently developed statistical reporting system for psychiatric outpatient clinics provides an opportunity for an overview of clinic services. In Texas we found that having our annual workshop of psychiatric clinic staffs immediately following the publication of the annual statistical report seemed to stimulate clinic staff thinking and resulted in productive discussion.

Developing New Services

New services can be divided into those which are initiated by the State mental health agency, those initiated by another State agency, and those initiated locally. This is an arbitrary grouping, and any of the following kinds of services could be initiated by any one of the three sources, but in our experience this grouping seems reasonable.

At the present time we are convinced that four professional groups, physicians, nurses, teachers, and clergy, are in a strategic position to foster the mental health of the people they serve. What is the State mental health agency's responsibility to them? Should we at least be aware of the extent to which the schools of medicine and nursing, the teachers colleges, and theological seminaries include in their regular curriculums indoctrination and training in concepts and methods in community mental health? The National Institute of Mental Health, Public Health Service, is providing grants to schools of nursing, among others, for this purpose. But it is our experience that the professional schools want to know how to integrate community mental health into their curriculums and how to relate this to professional practices in the State as a whole.

Another kind of new project, mentioned previously, might consist of detecting early cases of emotional or personality disturbance in gifted children and providing prompt treatment for them and their families. The State agency might initiate this service in one or more school systems and test it for several years. Such a program should be set up to encourage continuation by the schools following completion of the pilot project.

Many States have services for expectant

mothers through maternity clinics and for mothers and children in well-child clinics. Frequently such services have been initiated locally or through the maternal and child health programs. But what is the responsibility of the State mental health agency for seeing that the potentials of these services are utilized throughout the State?

More adequate interagency services to disorganized families are seldom initiated locally or by another State agency. The studies of Community Research Associates in St. Paul, Minn., (10) and elsewhere indicate that a small proportion of families produce a great proportion of the behavior and personality disorders as well as other problems in a given community. Few would question the assertion that community health, welfare, and education agencies are not collaborating extensively in making comprehensive family diagnoses, for example, or in providing long-term, integrated services to such families. Should the State mental health agency initiate and help plan such collaboration? Perhaps the State agency should at least initiate local conferences or studies on the maximum use of mental health clinics by local agencies.

The State agency might also initiate an epidemiological study of the incidence of various kinds of mental illnesses. A very modest study (11) we did recently revealed that of first admissions to mental hospitals, almost half of the patients and their families had been known to one or more local agencies within a 3-year period immediately prior to hospitalization. Such a study can generate local projects in level 4 prevention which involve systematic interagency collaboration and stimulate the setting up of a system of psychiatric consultation and other supplementary services to the agencies serving these families. Such services would help the agencies to stabilize the family, prevent illness which would require hospital care, and perhaps result in long-time rehabilitation of some families.

A project we co-sponsored in a Dallas, Tex., general hospital assumed that if a family member has a psychiatric illness so acute as to require hospital care, his family also may be sufficiently disorganized to require considerable long-range health and welfare services. A de-

liberate effort was made to marshal the various community health and welfare services for the families of the patients who are admitted for psychiatric treatment. We hope to learn if the assumption is accurate and whether the marshaling of the services results in some demonstrable long-term rehabilitation or maintains the health of these families, or both.

We need to remind ourselves frequently that community mental health is not the exclusive property of our agency. And since many other State agencies and organizations are vitally interested in, and frequently initiate, mental health services, it seems important for us to develop and maintain good communication with them. Some of these are the crippled children's services; programs dealing with tuberculosis, chronic disease, alcoholism, venereal disease, and occupational health; State departments of education; State universities, especially extension divisions; medical and nursing schools; housing agencies; divisions of child welfare; vocational rehabilitation agencies; institutional services for the mentally ill and mentally retarded children; and mental health associations.

A State agency for community mental health might well collaborate with one or more other State agencies to strengthen services for children deprived of maternal care. State child welfare agencies usually have the responsibility for licensing children's institutions. Children in such institutions are definitely a population at risk for whom few State mental health programs are doing anything.

Another program might be to provide psychiatric consultation in crippled children's clinics. Public schools have a variety of mental health services, many of them initiated by State departments of education or by local school systems.

We have hardly scratched the surface in developing industrial mental health programs, yet there is currently a great deal of interest in mental health among occupational health people. Projects to prevent delinquency are started almost daily, and the State mental health agency should at least be informed about them. Other currently popular projects are community rehabilitation of the mentally ill, mental health services to the chronically ill, and counseling services for the aged. Activities

often initiated by other agencies are teaching child development, parent-child relationships, and other topics through study groups such as those sponsored by local mental health associations. Another such program carried out by many universities is mental health inservice education, consultation, and similar services to agency staffs such as public health nurses, teachers, and other professional persons.

A broad new area that seems to be commanding a lot of attention is accident prevention, as exemplified by the special psychiatric project in Detroit, where persons who have second accidents involving drinking are required to have a psychiatric evaluation (12). In this way an effort is made to find the accident-prone or the severely disturbed persons, and a frightening number of people have been discovered who have really severe personality disorders.

We need to encourage the various agencies to take more and more responsibility for continuing all these projects. We are kidding ourselves if we think we can do the whole job. We can only serve as stimulators, collaborators, and helpers.

Any of the activities previously listed could also be initiated by a local agency or planning group. We have to consider the particular situation in any given State to determine whether such locally initiated services should be organized on a local, regional, or statewide basis. But wherever a project is set up and whoever initiates it, it does seem appropriate for the State agency to provide consultation in helping to define and clarify the problem which prompted the request for service. The extent to which we continue to help define the problem or engage actively in planning, organizing, and operating a project depends on the whole constellation of services that we are trying to carry out and the role we have assumed as a State agency.

Since we cannot cover the whole State with intensive services, we need to consider how best to undertake at least one or two demonstration projects in local areas. Before initiating such demonstrations, there must be a readiness in the community for the project and involvement of citizen leaders, and the project must have the potential for a long-term contribution to the broad objectives of the State program, as well

as to the immediate local situation. Such new projects may demonstrate a new kind of service, a new pattern of services, or a different application of existing services.

We think in the Texas program that probably the most important component of such a project is a built-in system of data recording for evaluation at the end of the project. Projects seem to require at least a full year of advance planning and, based on our experience during the last 4 years, at least 5 years of operation to accomplish lasting and convincing results.

In planning for a local project, staff must be adequate to meet the local demands for service, to handle community organization and interpretation activities, and to do the research work, including the project report. Such projects, we find, quickly generate more demands for service than the staff can handle, and it is extremely important to have sufficient staff, particularly persons assigned primarily to the research phases. The project might be aided either by a financial grant from the State agency or by lending a State agency staff member.

Policymaking, however, should be a function of a local representative group. We have used a written agreement in such projects, and have found it is valuable as a means of clearly defining the responsibilities of the two parties involved. If a community council exists, the new project should be developed by working in cooperation with and sometimes through it.

A staff development and training component is needed to develop the type of State community mental health program I have described. For many years most States have provided scholarships for the various mental health disciplines and have found this practice an effective method of recruitment. But as community mental health services move into untested kinds of program activities, the existing staff and the staff that is added as programs grow will need advanced training.

We think it is very important to work cooperatively with existing clinics and other psychiatric services and with universities and training centers to develop more training facilities within the State. If this is not feasible, regional agreements, similar to those developed by the Southern Regional Education Board,

can be worked out. Whether the staff development program is on a State or regional basis, we must inaugurate it early or we shall find ourselves with insufficient staff or a staff that is not able to move forward into new program areas.

Yet even the best staff is on shaky ground in attempting its program planning alone. Some mechanism is essential to obtain the counsel and advice of both professional and citizen leaders in shaping broad program outlines. The staff will be kept closer to reality if there is a general advisory committee or a general committee and a technical committee.

Program Criteria

The following tentative criteria for a comprehensive, effective, and reasonable State program for community mental health are based on the foregoing assumptions, principles, and questions. As we become more experienced, the list should be critically reviewed and revised at regular intervals.

1. Are all four levels of prevention covered by some agency in the State if not by the State mental health agency?

2. Are existing services being developed with an attitude of experimentation, testing, and re-testing?

3. Are there areas of activity with both well-known and less well-recognized risk groups?

4. Is there a built-in evaluation component for all program activities?

5. Are program areas being planned and carried out in cooperation with other agencies to stimulate them to expand their own preventive activities in mental health?

6. Are at least some program areas of the State agency tangible, dramatic, and convincing?

7. Does the program encourage citizen as

well as professional participation in policy-making, at both the State and local levels?

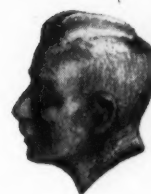
8. Is the program's content timed both for current public concern and long-range needs of the State?

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New Water Pollution Control Division

A new Division of Water Pollution Control has been established in the Bureau of State Services, Public Health Service. Gordon E. McCallum, former chief of the Water Supply and Water Pollution Branch, Division of Sanitary Engineering Services, will head the new division.



Inapparent Infection

Relation of Latent and Dormant Infections To Microbial Persistence

WALSH McDERMOTT, M.D.

BOTH microbes and man have an extraordinary degree of adaptive plasticity with reference to their respective environments. For centuries, man has been constantly changing his external environment and using his adaptive capacity to survive therein. In recent decades, however, man has greatly increased his capacity to alter his internal environment. And, it is man's now frequently altered internal environment to which the microbes that inhabit man must adapt if they are to survive.

When the Cornell University Medical College opened for the new term in the fall of 1958, I happened to draw the assignment of

Dr. McDermott, who is Livingston Farrand Professor of public health and preventive medicine at Cornell University Medical College, delivered the Dyer Lecture on December 16, 1958, at the National Institutes of Health, Public Health Service. A leading investigator in the field of infectious diseases, he has authored a large number of articles for scientific journals and contributed to medical classics on chemotherapy, pneumonia, and syphilis. He has also held posts of distinction on advisory and study panels of the Public Health Service.

discussing the first case at the clinical-pathological conference. The case record started off as follows:

A 43-year-old white Italian stock clerk was admitted to the New York Hospital-Cornell Medical Center for the first time June 4, 1957, complaining of swelling and tenderness of the right shoulder of 12 weeks' duration.

The patient was in good health until 3 months prior to admission when he noted the onset of swelling of the right arm from shoulder to wrist. This was shortly followed by fever and night sweats. Eight weeks prior to admission the right arm became painful. Shortly thereafter the skin over the right elbow became red and warm and the swelling increased. Despite initial improvement with corticotropin, steroids, and physical therapy, the discomfort in the right arm increased and admission was advised. A firm small right supraclavicular mass had been present for about 18 months. He had had an episode of "dry" pleurisy at age 21. One brother was known to have multiple cutaneous lipomata.

Physical examination revealed a well-developed, well-nourished white male who appeared neither acutely nor chronically ill. . . .

I shall omit the detailed presentation of the remainder of the findings in this case. I simply wish to call to your attention that the man was 43 years old, had considered himself to be per-

fectly well until 3 months previously, and on physical examination had appeared neither acutely nor chronically ill.

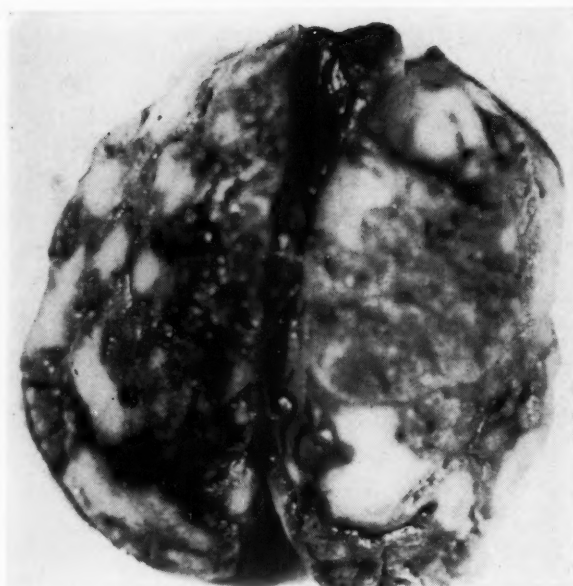
Revival of Microbial Slumberers

During the next 7 months this man had many trials and tribulations including such things as widespread tuberculosis of lymph nodes and lymphosarcoma. His multiple serious ailments were all brought under excellent control by the careful and wisely chosen application of some of the wonders of modern medical science. Indeed, he attained a symptom-free state and was able to leave the hospital for a short period. Nevertheless, this gallant patient and his most dedicated physicians were finally conquered by his developing an infection with *Monilia albicans*, a common microbe that characteristically lives harmlessly in man.

Presumably, when the patient was born he was not carrying *Monilia* but neither is there any reason to believe that he "caught" the monilial infection in the weeks preceding his death. In all probability, throughout most of his adult life the microbes of *Monilia* were living quietly somewhere in his tissues. This was presumably the case whether or not by our relatively crude diagnostic methods it would have been possible to detect them there amid the welter of other microbes for which he played the host. The point that concerns us is the fact that from this welter of other micro-organisms it was this particular one, *Monilia*, that found the environmental conditions for arising and conquering. In short: Why *Monilia*?

Let us turn now from the bedside to the laboratory and regard other examples of infection. Some 7 or 8 years ago, as was correctly fashionable at the time, we were engaged in our laboratory in studying the influence of cortisone and corticotropin on infections, notably experimental infections with tubercle bacilli.

In one part of these studies, LeMaistre and Tompsett chose a model consisting of avian tubercle bacilli and the rat, in order to have an infection that was generally mild in character (1). In figure 1 may be seen the type of caseating necrotic lesion observed in the lungs of the rats infected with avian tubercle bacilli and maintained on cortisone. The avian tu-



Reproduced with the permission of the Journal of Experimental Medicine, reference 1.

Figure 1. Lesions of the lung of a rat which received cortisone but was not inoculated with tubercle bacilli.

bercle bacilli could be recovered by culture of these tissues.

The initial inference was the natural one that a characteristically mild tuberculous infection had been enhanced to the point of fulminating caseonecrotic disease by the influence of the cortisone. On more careful study, however, it was revealed that the avian tubercle bacilli had nothing to do with these caseonecrotic lesions. Instead, it was found that the entire process was a disease known as pseudotuberculosis produced by quite a different microbe, *Corynebacterium pseudotuberculosis muris*.

In the absence of cortisone, the members of the rat colony uniformly showed a high degree of natural resistance to the corynebacteria when attempts were made to infect them by various routes. For this and other reasons it seemed wholly improbable that the corynebacterial infection in the animals given cortisone represented a cross-infection occurring after the start of the cortisone. Despite careful and detailed investigation, however, it was not possible to demonstrate that the rats were already harboring the corynebacteria at the time they received the cortisone.

In other words, by the use of all available

diagnostic methods it was not possible to detect the presence of corynebacteria in the tissues of the rats. Yet the evidence was quite convincing that the corynebacteria in fact were there; it was just not possible to demonstrate that they were there. Once the rats received cortisone, this infection—that could not be introduced experimentally from the outside—exploded “from the inside,” so to speak, and formed a tissue-destroying and eventually fatal disease.

The question arises as to whether it was the presence of the latent corynebacterial infection or the absence of the appropriate tissue environment that created the host resistance against our attempts at experimental infection. In any case, once the cortisone influence was established, it was the corynebacteria, and not any of the other microbial species residing in the rats, that were resurrected to the production of destructive disease. Once again we may well inquire: Why *Corynebacterium*?

In this particular case we do have a little more of a lead from studies, some by LeMaistre and others and some by György and by Zucker and their associates in the precortisone era (2, 3). These studies have shown that certain specific dietary deficiencies can provide the appropriate environment for the resurrection of *Corynebacterium* in the tissues. In short, we have a glimpse here of the sort of specificity that we sense must be present in these microbial adaptations to their environment.

Retreat Into Latency

The two examples cited thus far have been concerned with one end of a phenomenon: the apparent resurrection of a microbial slumberer that is then able to surpass its fellow competitors so successfully that it finally overcomes its host. Let us turn now to what might be viewed as the other end of the phenomenon, namely, how a microbe that is surrounded by a tissue environment wholly appropriate for its flowering as disease nevertheless assumes the latent state. How does the microbe that is living openly in the host “go underground?” Or, more precisely, can either the microbe or the ideal tissue environment be artificially modified so that microbial latency is the outcome?

An approach here that immediately comes to

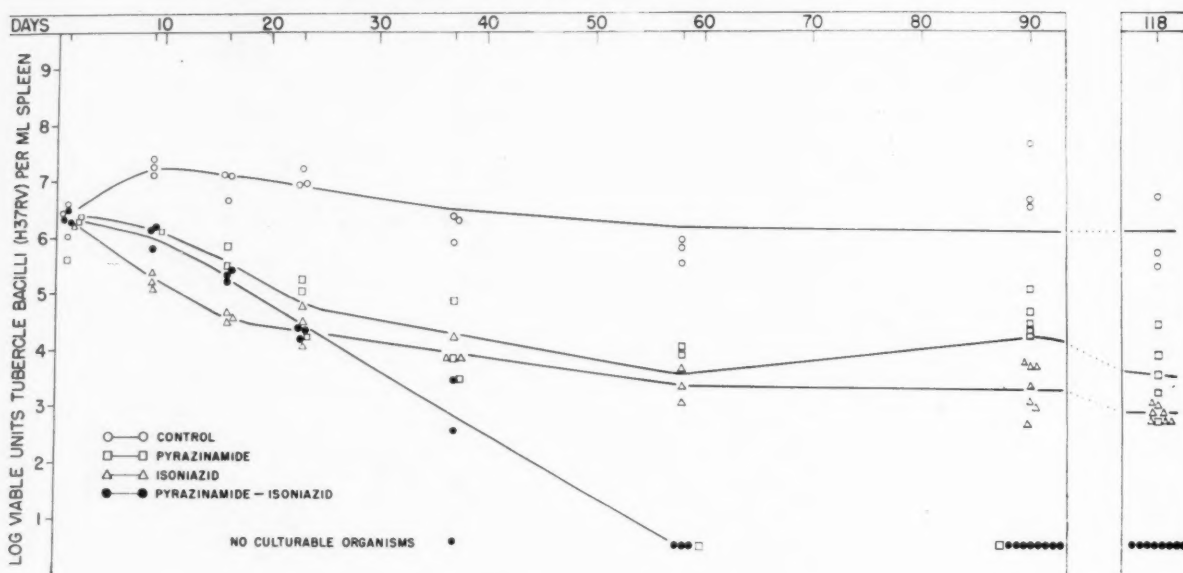
mind is to modify the tissue environment by infiltrating it with one or more antimicrobial drugs. For the past 15 years or so our group at Cornell has been attempting to do just this. And, I can say that we have found only one situation in which it has been possible regularly to make an infection vanish from the tissues.

In all other situations with a variety of microbial species and a large number of antimicrobial drugs, the most that it has been possible to do is to keep an infection suppressed at very low but detectable levels in the tissues. The one exception has to do with tubercle bacilli of human origin and a derivative of the nicotinamide series known as pyrazinamide.

When tubercle bacilli subsisting in the tissues of the mouse are simultaneously exposed to pyrazinamide and another antituberculous drug for an appropriate period, all of the tubercle bacilli vanish from the tissues of the animals. By “vanish” is meant that the presence of tubercle bacilli in the animal tissues can no longer be demonstrated by the most elaborate techniques of microscopy, culture, or animal inoculation. The administration of pyrazinamide alone will likewise cause the tubercle bacilli to vanish if they have just previously been exposed to isoniazid for an appropriate period. When the pyrazinamide is administered entirely alone, that is, without either prior or concomitant administration of another drug, the vanishing phenomenon does not occur, and the effects of pyrazinamide seem to be of the same type as those of other antituberculous drugs, notably isoniazid. In the last-named circumstances, the populations of tubercle bacilli in the animal tissues steadily fall during the early weeks of chemotherapy and then stabilize at a low census at which they persist throughout many months of continued chemotherapy. These two phenomena, the vanishing of “drug-influenced” tubercle bacilli when exposed to pyrazinamide and the persistence of tubercle bacilli when exposed to isoniazid or to pyrazinamide alone, may be seen in figure 2, which depicts an experiment that has been repeated many times (4).

In actuality, the vanishing of the bacilli does not represent their complete elimination from the tissues of all the animals. When a 90-day period of pyrazinamide-isoniazid administra-

Figure 2. Influence of pyrazinamide and isoniazid used singly and together on populations of tubercle bacilli in mouse spleens during 118 days of therapy.¹



Reproduced, with permission, from the *Journal of Experimental Medicine* 104: 767 (1956).

¹ Infecting inoculum: 2.0×10^6 culturable units of tubercle bacilli.

tion was followed by a 90-day treatment-free interval, the bacilli reappeared in approximately one-third of the animals. In these animals, therefore, a truly latent infection had been induced with spontaneous resurrection after a drug-free interval of 60 to 90 days. Whether the other animals that showed no microbial revival in the 90-day period of observation also had latent infection cannot be stated, but we believe it to be the case.

There are obvious parallels between this artificially induced latent infection with tubercle bacilli and the latent monilial and corynebacterial infections of the man and the rats. In all three cases there was a stage at which there is every reason to believe that the microbes were present in the tissues, yet not the slightest trace of their presence there could be detected. In all three cases the resurrection from the latent state did not occur until the tissue environment, the external environment of the microbe, had undergone some modification. With the corynebacterial infection of the rats, the change in the nature of the environment provided by the tissue represented some consequence of cortisone.

With the fatal monilial infection of the man, the nature of the environmental change in the tissues is not clear, but the various microbial species in natural competition with *Monilia* had been suppressed and cortisone had also been given. With the infection made latent artificially, the usual environment provided for the tubercle bacilli by the tissues of the mouse was obviously perfectly suitable for the full expression of the microbes. Consequently, for microbial resurrection no tissue modification was necessary other than to free the environment of the pyrazinamide.

The two examples of "naturally" occurring inapparent infection that have been chosen were simply those most readily at hand and represent the expression of the phenomenon by a fungus and by a bacterium. A familiar example of inapparent infection with a virus is provided by the commonplace happening of the breaking out of cold sores around the lips caused by resurrection of the virus of herpes simplex. In an infected person, this event will occur predictably when the environment provided for the virus by the tissues has been modified by such factors as fever, excessive sun-

light, digestive upsets, or menstruation. As techniques for tissue culture have been developed it has become clear that the cells employed are not infrequently the site of an inapparent infection. Another case in point is the activation of an inapparent viral infection of bacteria, a bacteriophage, by appropriate change in the environment, with resultant destruction of the bacteria. Thus it is becoming increasingly recognized that inapparent infection is a broad biological phenomenon involving all sorts of microbes and every sort of host including man, lower animals, plants, and even the microbes themselves.

In the present discussion no attempt will be made to cover this field throughout its entire breadth. Dubos has a recent publication on latent infection (5), and one of his associates, Dr. Harold Simon, has virtually completed a comprehensive review of the subject which is scheduled to appear as a monograph in the latter half of 1959. Consequently, in the following discussion, attention is limited to the phenomenon of inapparent infection as it applies to bacteria and fungi because here, with antimicrobial drugs, it is possible to manipulate inapparent infections and to draw certain relatively elementary inferences concerning their nature.

The Dormant State

Thus far, the discussion of inapparent infections has centered around latent infections. It seems to me that a latent infection can be regarded as an extreme form of microbial adaptation. For, inapparent infection can exist and eventually give rise to serious disease without the microbes ever having assumed a truly latent form. In a sense, this is merely semantics, but I have found it helpful to follow the practice of subdividing infections into those which are latent and those which are dormant.

The term "latent infection" is reserved for situations in which the presence of the microbes cannot be demonstrated by any method now available and the fact that infection is present can only be demonstrated in retrospect by the emergence of overt disease (usually as a relapse).

A dormant infection is one in which the presence of the microbes can be easily demonstrated

but they are not producing disease. In a dormant infection, the micro-organisms may be living openly as the so-called commensals in the respiratory or enteric flora or less obviously in the healed lesions of previous disease as in those of the tuberculin reactor and probably also the typhoid carrier.

As we view things today, the emergence from inapparent infection to openly progressive disease occurs far more frequently with dormant infections than it does with latent infections. This could change, however, and especially what could change are our techniques for detecting the presence of latent infections.

The Antimicrobial Drug

In attempting to analyze the phenomenon of microbial persistence it has seemed to me that there are five possibilities that merit consideration:

The first two are the possibilities that drug resistance of the genotypic form or inadequate drug dosage might be responsible. These can be dismissed from further consideration by virtue of the fact that experiments designed to test these possibilities have shown that they do not apply. Likewise a third possibility that microbial persistence is a result of a failure of the delivery of the drug to the parasite because of impenetrable barriers by abscess walls, fibrin membranes, or areas of necrosis can also be dismissed on the basis of appropriate experiments conducted both in our own laboratory and elsewhere.

One aspect of this barrier question does deserve special mention, however, and that is the effectiveness of intracellular residence as a sanctuary from drugs present in the intracellular fluid.

We are accustomed to hear the statement that such and such an antimicrobial drug "does not penetrate the monocyte" or some other type of cell. It is not generally realized that the type of experiment cited is not usually designed to measure whether the drug is or is not transferred across the cell boundary. Instead what is actually shown in most such experiments is that a particular microbial species, when situated within a cell, is less susceptible to a particular drug introduced into the extra-

cellular environment than is the case when both the microbe and the drug are allowed to come together outside the cell.

In short what one observes is that microbes within cells are less drug susceptible than microbes outside cells; what one *infers* is that the drug was not transferred into the cell.

In reality, in the few cases in which the actual transfer of a drug has been measured, such as in Eagle's careful studies with isotopically labeled penicillin at the National Institutes of Health (7), it is found that quite substantial quantities of drug are transferred. Indeed, the quantities of penicillin transferred are more than sufficient to exert full effectiveness, so when the intracellular microbes are not fully susceptible, and sometimes they are not, some other explanation must be found.

From Eagle's studies on penicillin transfer and from some observations on penicillin-staphylococcus-leucocyte systems by Tompsett (8), it does not appear that the persistence of a minority of the intracellular staphylococci is due to a failure in drug delivery. Instead, the persistence within the phagocyte seems to be merely a replica in miniature of microbial persistence in the body as a whole.

The fourth possibility is that the environment of the inflammatory lesion exerts an antagonistic influence on the activity of the antimicrobial drug.

Although in the past I have done as much as anyone to promulgate this concept, I no longer believe it will stand up to critical scrutiny (9). It is easy to show that environmental changes result in changes in drug effectiveness. This is particularly striking in the fact that the same microbial species situated in the different organs of the same animal show widely different susceptibility to the same drug. For example, tubercle bacilli in the lung of the mouse are far more susceptible to isoniazid than tubercle bacilli in the spleen. Moreover, tubercle bacilli in the spleen are far less susceptible to streptomycin than the staphylococci in the spleen of the same animal species.

When tested in conventional circumstances in vitro, tubercle bacilli are quite unaffected by pyrazinamide. When the environment of the bacilli is altered, however, either by making it

more acidic or by situating the bacilli within monocytes, tubercle bacilli of human (but not bovine) origin become highly susceptible to pyrazinamide. A recent report by Williamson (10) shows that a change from an anaerobic to an aerobic environment doubles the effectiveness of dihydrostreptomycin on *Escherichia coli* over a wide range of pH. By contrast, with *Aerobacter aerogenes*, the enhanced drug activity in the aerobic environment occurs only at pH 7 or above. Since in both sets of circumstances the drug is the same, the effect of the environmental change on drug influence must be something directly related to the parasite and not a direct environmental antagonism of the drug.

Thus a number of examples exist wherein a change in environment has been accompanied by a change in drug effectiveness. In each case, however, the result could equally well have represented an influence of the environment on the parasite. Some of the examples of environmental influence, moreover, represent influences that could only have been exerted on the parasite. In view of these considerations together with the fact that a large excess of drug should usually be present in the lesion, it appears that environmental antagonisms of drug activity may well occur, but that seldom, if ever, should it attain a magnitude that would provide a satisfactory explanation for the phenomenon of microbial persistence.

The State of Drug Indifference

The fifth possibility is the one that in my opinion fits the evidence. In brief, the concept is that microbial persistence is the result of the ability of microbial populations to assume a state in which they are neither permanently incapacitated by a drug nor do they multiply freely in its presence as do the genetically drug-resistant microbes.

I have designated this state, which can be demonstrated in vitro and in vivo, as "drug indifference."

The concept of drug indifference does not imply marked suppression of all metabolic functions of a microbe but merely those related to a particular drug. The metabolic functions do not necessarily continue throughout the life

of the microbe but might have to do exclusively with activities of its early youth, for example, cell-wall synthesis. In such a case, the newborn microbe might resemble a protoplast with its capacity to carry on metabolic functions including limited cell division but without the capacity to multiply freely (6, 22).

It is believed that the assumption of this state of drug indifference is induced or favored by the influence of the environment on the microbe. Included in these environmental influences are other antimicrobial drugs and intermicrobial relationships as well as the influences of the cellular and humoral defense reactions of the host and the reactions of inflammation. An environmental change of a particular sort may make the same parasite display widely different behavior to different drugs or may make different parasites display less than their maximal susceptibility to the same drug. For these reasons it is believed that it is the adaptive plasticity of the microbe that is the important factor in the influence of environment on drug effectiveness and not a chemical or physical antagonism exerted directly by the environment on the drug.

Expressed differently, pus does not neutralize drug activity, but in adapting to a necrotic environment a microbe may become less susceptible to a drug. Although instances of drug enhancement from environmental adaptation of the microbes do occur, thus far they have not been observed to lead to total eradication of a microbial population. Consequently, the net overall effect of the various environmental influences on drug effectiveness is in the direction of providing situations that favor microbial persistence.

Presumably this state, or these states, of drug indifference closely resemble, perhaps are identical to, the microbial states associated with latent or with dormant infections. Thus in concept, if not in actuality, microbial persistence may be regarded as merely the induction of the latent or the dormant microbial state by drugs.

The Parasite's Morphological Changes

Consideration of the phenomenon of microbes in the latent or in the dormant state naturally gives rise to speculation on the possible nature of such states. This is particu-

larly the case with the latent state because the question immediately arises as to the form that could be assumed by the tubercle bacilli or the corynebacteria so that they might be able to exist in the tissues without our being able to find them.

In the first place, it must be recognized that our methods for microbial detection are so relatively crude that the microbes need not change their form in order to "vanish" completely. All that would be necessary would be for the microbes to lose the ability to grow on our artificial culture media. A population of tubercle bacilli, for example, must be quite large before it is readily detectable by direct microscopy so that if it had lost its ability to adapt to artificial media, it would be undetectable.

In recent years the concept that microbes might possibly exist in more than one form has become respectable, almost fashionable. Moreover, with full realization that our inability to detect microbes during latency may simply reflect the crudity of our diagnostic methods, there remain, nevertheless, certain features of latency that suggest a major change in the form of the microbe.

The principal feature has to do with the time sequences involved in the pyrazinamide-induced latent tuberculous infection. For the uniform induction of latency, a total period of 12 weeks of chemotherapy was required. The pyrazinamide and companion drug could be administered together for the entire 12-week period or 4 weeks of treatment with isoniazid followed by 8 weeks of pyrazinamide could also suffice. But variations of these time-dose relationships, keeping the 12-week period constant, would not suffice. For example, merely reversing the order in which the two drugs were given in the sequential experiments or reducing the initial isoniazid therapy to 2 weeks instead of 4 weeks would result in a failure to induce latency. Obviously, a number of inferences are possible from these observations, but the relative precision of the time-dose requirements suggests the operation of some process that requires considerable time.

The resurrection of the tubercle bacilli from the latent state likewise required a considerable period. It must be remembered moreover, that the tissue environment in which the resurrec-

tion occurs is presumably quite favorable for the proliferation of the tubercle bacilli. Yet in the animals in which the bacilli reappear after a 90-day treatment-free interval, it has not been possible to demonstrate their presence at the 30-day or the 60-day observation point. Even when sufficient cortisone is given to evoke other microbes during the first 30 days after therapy, no resurgence of the tubercle bacilli has been demonstrated.

This appreciable delay in the reappearance of the tubercle bacilli in an apparently favorable environment and our inability as yet to hasten the process by artificial "stresses" suggest that a significant modification of the parasite was necessary before resurrection could occur. In other words, the time relations suggest that the microbial adaptation represented by the latent state of tubercle bacilli is not something that is rapidly responsive to transient fluctuations in the status of the host defenses. By contrast, resurrection of tubercle bacilli from the dormant state can occur with rapidity. The speed with which resurrection from the latent state (as contrasted with awakening from the dormant state) occurs might vary considerably among the microbial species and might likewise depend, to some extent, on the rapidity with which the appropriate environmental alterations could be accomplished.

What could be the nature of a morphological change that might accompany the physiological state of latency? Certain studies of this general subject of the existence of other forms of well-known microbes have employed antimicrobial drugs, notably penicillin, to induce the novel microbial forms. This was the case with the minute colonial forms of staphylococci, the so-called dwarf forms, and more recently with the studies of L-forms and bacterial protoplasts.

When the outer, rigid wall of a bacterial cell is removed under appropriate conditions (or its synthesis prevented), the bacterial cytoplasm and its cytoplasmic membrane may continue to exist. This surviving unit is known as the protoplast. The protoplast can carry on many, perhaps all, of the metabolic functions of the original cell except cell-wall synthesis.

It is the process of cell-wall synthesis that

appears to represent the site of action of penicillin and the protoplasts of penicillin-susceptible microbes are unaffected by penicillin. The protoplasts also appear to possess the capacity to multiply but to what extent such newborn protoplasts can survive is not yet established. These minute "peeled grapes," so-to-speak, are quite fragile and are especially susceptible to oxygen and to changes in the osmolarity of the environment.

There is some reason to believe that all protoplasts from the same microbial species are not alike. Consequently, Weibull, who is one of the outstanding investigators in this field, believes it is valuable to distinguish between true protoplasts in which no trace of the outer cell wall remains, and "protoplasts" or protoplast-like structures to which some fragment of a cell wall may remain (11). Weibull regards true protoplast formation as being something that has been clearly demonstrated for only a few microbial species and the protoplast-like phenomenon as being something more common.

In any case, the literature today contains a number of reports of observed "protoplast" formation among such micro-organisms as staphylococci, tubercle bacilli, enterococci, and many others. Moreover, a number of workers have come to regard the process of protoplast formation as being identical with what happens in the first stage of the formation of the L-form from the normal vegetative form of certain bacteria.

Despite their fragility, protoplasts can survive in vitro with appropriate manipulations of the environment. Moreover, if L-forms are protoplasts or protoplast-like structures, they would represent one form that survives in vitro where indeed the osmotic homeostasis might be expected to be more protective.

Wittler and associates in Washington have shown that the L-form of corynebacteria can be converted to the familiar vegetative form in HeLa cells by appropriate changes in the environment of the host cells (12). Wittler has also shown the same phenomenon for *Haemophilus pertussis* in mouse tissues (13).

Thus there is accumulating quite a respectable body of evidence to the effect that many microbial species are capable of responding to

environmental change by assuming quite a different form and that this may occur within the animal body. It is of interest that the corynebacteria and mycobacteria involved in the two latent infections I have been using as illustrations are included in the list of organisms that can assume a protoplast-like form. Moreover, it is especially relevant to the present discussion to note that for some microbial species protoplast formation can be regularly induced by appropriate exposure to penicillin. The protoplasts so induced are not destroyed by penicillin, and when the penicillin is removed from the environment the protoplasts revert to the vegetative (and penicillin-susceptible) form of the microbe.

Obviously, it would be intriguing to attempt to study the pyrazinamide-tubercle bacillus relationship from the standpoint of protoplast formation especially in view of the long period necessary for microbial resurrection in the tissues.

As mentioned previously, however, we must keep constantly in mind the fact that our detection techniques for the customary forms of bacteria are so relatively crude that nonculturable but morphologically typical microbes could survive undetected in the tissues.

It might well be questioned whether there is any value in attempting to divide inapparent infections into those which are dormant and those which are latent on so artificial a basis as the ability or inability to detect the infective agent at a particular point in time. As long as this contrivance does not make us prisoners of our thinking, I believe it serves a useful purpose at this time when our knowledge is so elementary. For, the distinction keeps open the prospect that in a latent infection the microbe may be structurally and functionally in a state quite different from the microbe of overt disease or the carrier state. Along with this goes the corollary possibility that in the phenomenon of resurrection from latency to overt disease, the activation of complicated mechanisms within the parasite may be as essential as the appropriate changes in the environment provided by the host. By contrast, with a dormant infection all that may be necessary is a lapse in host defenses for the infection to become disease.

Microbial Persistence

Let us return now to consideration of experimentally induced latent and dormant infections in laboratory animals. As you will recall it was emphasized that the vanishing of the drug-influenced tubercle bacilli when they were subsequently or concurrently exposed to pyrazinamide in the tissues represented the only instance in our experience in which a microbe became truly latent as a consequence of chemotherapy. This experience includes studies with staphylococci, streptococci, *Klebsiella*, and *Brucella* as well as tubercle bacilli, and it includes all of the available antimicrobial drugs. In the case of tubercle bacilli alone, some 13 drugs with demonstrable antituberculous activity have been studied when administered singly and in various multiple drug regimens. With two compounds, a thioamide of nicotinic acid and streptovaricin, results approaching those of the pyrazinamide phenomenon were noted, but true latency could never be produced with uniformity throughout all the animals studied.

Obviously, tubercle bacilli possess the equipment to assume the latent state, but the process apparently has to be invoked in some highly specific way. Some notion of the degree of specificity that must be involved may be seen from the fact that this capacity of human tubercle bacilli to respond to pyrazinamide by assuming latency is not shared by the very closely related tubercle bacilli of bovine origin. At least one other microbe, *Treponema pallidum*, probably possesses the capacity to assume the latent state both in rabbits and man as a result of drug exposure. This point cannot be established with certainty, however, because of our lack of culture techniques whereby the tissues could be subjected to reasonably searching scrutiny to show the nondetectability of the treponemas during a latent state.

In contrast with the rarity of drug-induced latent infections, the production of dormant infections occurs regularly with all microbes studied when exposed in the tissues to an appropriate antimicrobial drug. Indeed in the experiments with latent tuberculous infections, dormant infections were produced in the groups of animals that received isoniazid or pyrazinamide as single drug therapy (fig. 2). In each case, the populations of tubercle bacilli fell

sharply after the start of drug therapy but then stabilized at a low census at which they remained throughout the many weeks of continued therapy.

As mentioned previously, this survival of the microbes in the tissues at a constant low census despite appropriate drug therapy can be shown for a number of microbial species and all available antimicrobial drugs. Indeed this phenomenon, which I like to designate microbial persistence, represents a biological property of very broad but perhaps not unlimited generality. In the treatment of infections in humans, the existence of the phenomenon of microbial persistence need not necessarily lead to therapeutic failure but most failures that occur stem from it. Moreover, in addition to providing the basis for post-treatment relapse, microbial persistence is obviously responsible for the post-treatment carrier state. In short, it is this phenomenon which is responsible for our inability to eradicate an infection uniformly from a group of patients or from a community by the use of drugs.

Our group at Cornell has been specially preoccupied with this phenomenon of microbial persistence ever since early 1946. An extensive review of these studies has been published recently (6). Accordingly, I shall attempt to present the subject only in sufficient outline to provide a proper basis for a subsequent consideration of latent and dormant infections. In so doing it will be necessary to employ bold assertions at certain points without bringing forward the experimental evidence that has seemed to me to be convincing. This evidence is offered in the published presentation.

In this brief consideration of microbial persistence, we start from the demonstration both in patients and in laboratory animals that microbes that are drug susceptible in the orthodox sense are nevertheless able to survive in the tissues despite the prolonged administration of the appropriate antimicrobial therapy. The horizontal trend lines of the census of microbes during therapy seen in figure 2 are merely one graphic representation of this point. Indeed, about the only situations in which antimicrobial therapy can be totally eradicated in humans are with the relatively fragile *Neisseria* and possibly also with dysentery bacilli.

The close resemblance of the microbial states of drug indifference to those of the naturally occurring latent and dormant infections may be seen in the phenomenon of drug-resistant "persisters." It is quite clear that the general phenomenon of microbial persistence is not a result of the presence or emergence of genotypically drug-resistant microbes. Indeed with the experimental model employed in figure 2, when a microbial population is resistant to a particular drug the census in the tissues does not fall on administration of the drug. Moreover, when the population is drug susceptible at the beginning but is transformed in the course of therapy to one that is drug resistant, the drug-induced downward trend of the census is reversed and the microbes proliferate freely in spite of the continued administration of the drug. But sometimes this microbial resurgence does not occur. Instead the population that has been markedly reduced by drug therapy (and is now predominantly drug resistant) simply remains at the low census throughout long periods of continued drug therapy. In short, the drug-resistant microbes behave like drug-susceptible persisters.

Unfortunately, it has not been possible to conduct the obvious experiments on the fate of these drug-resistant persisters in the period after the antimicrobial therapy has been discontinued. It is possible, however, that the situation here may resemble the paradoxical situation discussed below in connection with chemoprophylaxis in which a microbial population that is drug indifferent is nevertheless under the continued influence of the drug. What can be said at this point about the resistant persisters, however, is that microbial populations (including the drug-resistant cells) obviously can become dormant or latent within an animal body by processes not necessarily dependent on antimicrobial therapy.

The possible morphological changes in the microbe to go along with the altered metabolic states have been considered in terms of latent rather than dormant infections. The latent state appears to represent a more extreme form of microbial adaptation than the dormant state, and hence it is to the latent state that attention is understandably directed. Obviously, it cannot be stated at this time whether the mi-

crobes in a dormant infection have the capacity to assume different morphological states. In contrast with a latent infection, however, there is in a dormant infection no delay or difficulty in cultivating the microbes in their orthodox form.

Before leaving this question of possible morphological changes in the parasite in the tissues, I should like to make a brief comment on the matter of the role of the host in maintaining an infection in the dormant or the latent state. Presumably, the host plays an important role here both through the known host mechanisms of defense, by similar mechanisms as yet unrevealed, and by not providing certain types of environment such as those produced in the tissues during starvation or in the cortisone-treated animal. What I would like to point out, however, is that in quite properly focusing our attention on the host in the host-parasite reaction we have tended to regard the parasite as something that is passive and relatively constant in nature whether it is actively producing disease or living quietly in the tissues. In so doing we have tended to regard the difference between the latent and the active stages of an infection as depending almost entirely on the momentary status of the host defenses and have been neglecting the wide range of individual expression possessed by the parasite. It seems quite likely that evocation of an infection from the latent state might require some rather substantial adaptive changes by the parasite and not merely a failure of some defense mechanisms of the host. The difference between a dormant infection such as an arrested tuberculous lesion in the lung and a latent infection such as syphilis might hinge on this very point: that for resurrection to disease, the latter would require changes in the microbe itself.

Point of Drug Susceptibility

While considering the role of the host in maintaining an infection in the dormant or latent state it is also appropriate to consider to what extent antimicrobial therapy can exert an influence in this respect. The question might be phrased by inquiring whether microbes that are not actively producing disease are likely to be drug susceptible. A fair amount of information is available on this point. The

information is derived both from laboratory studies and from five clinical situations in which it has been possible to observe the effects of drug therapy administered in the early hours after the moment of infection. In all five clinical examples (syphilis, malaria, scrub typhus, tuberculosis, Q fever), the antimicrobial therapy was not eradicated, but simply held the situation frozen, so-to-speak, for as long as its administration was continued.

The observations on these various diseases suggest that there exists a stage to which the host-parasite reaction must mature before the infection is fully drug susceptible as measured by post-treatment relapse (9). In the Tigertt-Benenson studies of Q fever it was shown that this particular stage of maturity is not necessarily so old as the stage of evolution to the full clinical illness (14). When the treatment was started before this stage, however, it was clearly ineffective and served only to produce a slight prolongation of the incubation period of the clinical illness.

From these five clinical examples (6-9) and especially the two that were conducted experimentally by Smadel and Woodward and their associates (15) and by Tigertt and Benenson, it is clear that the phenomenon of drug indifference or microbial persistence can be present from the very beginning of an infection. Even at the earliest stages of an infection when the untreated microbial population is presumably at its lowest census, the introduction of antimicrobial therapy is by no means totally eradicated. In these circumstances, moreover, it is important to note that microbial persistence can occur without evoking the host-immune response characteristic of that particular infection. As a practical matter it makes no real difference whether certain microbes in an infecting population are drug indifferent at the time of implantation or whether the whole process of conversion to drug indifference occurs after infection has been accomplished and drug therapy started. In either case drug indifference can be present in the early moments of infection, and this fact is obviously of crucial importance with respect to chemoprophylaxis.

Many factors are presumably involved in the successful transmission of one or more microbes from one host to another, and the actual physi-

cal transfer of an infecting population to a new host is not necessarily followed by their successful maintenance there. The presence of a prophylactically administered drug in the fluids of the new host might well make the difference between the success or the failure of the implanted microbes to survive. What must be recognized, however, is that even if an antimicrobial drug is present in the tissue fluids at the time of the initial microbial seeding there is no reason to doubt that some of the microbes may survive as persisters. Consequently, the possibility seems highly likely that chemoprophylaxis—to the extent that it is employed to try to prevent actual infection—will only be uniformly successful with the very few highly fragile microbes, such as gonococci, meningococci, or dysentery bacilli, that appear to have little capacity to survive as persisters.

Although the premature drug therapy was ultimately unsuccessful in the five examples cited, it was clear that the infections were suppressed as long as the antimicrobial therapy was continued. This implies that the microbial populations were both drug indifferent and drug influenced at the same time. Presumably, what happens in this apparently paradoxical situation is that a significant proportion of the microbial population is in fact drug indifferent and remains so. But as the tissue environment contains antimicrobial drug, whenever individual microbes revert from drug indifference to a state of drug susceptibility or new cells are born into this state they are promptly inhibited by the drug. As a result the population as a whole is kept constantly suppressed, a condition I like to describe as being in a state of physiological imprisonment.

In the clinical instances cited, the physiologically imprisoned microbes were able to resurge to the point of producing clinical illness once the antimicrobial drug was removed from the tissue environment. It is conceivable that if the physiological imprisonment were maintained for a sufficiently long period, the microbial populations might die off completely in some cases and in others assume a latent or dormant state that would continue even in the absence of drug. Presumably something akin to the last-named possibility occurs in the puzzling case of drug-resistant persisters.

It would hardly be proper, in a discussion of inapparent infection, to fail to note the possibility that latent or dormant infections, either natural or drug associated, are capable of damaging the tissues by their continued presence there. This is the sort of speculative exercise that can rapidly get out of hand. Nevertheless, it seems appropriate to mention a few diseases, associated with microbial infection, in which demonstration of the indicted microbe in the tissues in its recognizable form has either never been accomplished or has been accomplished only rarely. The two principal diseases in this category are syphilis and rheumatic fever. Sarcoidosis might possibly represent a third example, but the indirect association of these lesions with tubercle bacilli is considerably less definite than the indirect association of rheumatic carditis with streptococci or tabes dorsalis with *T. pallidum*.

The fact that tabes dorsalis is caused by *T. pallidum* is generally accepted, yet the presence of the spirochete in the lesions has never been convincingly demonstrated. To some extent this situation is not comparable with that of other infections because no method exists whereby *T. pallidum* can be cultured. Nevertheless, *T. pallidum* can be demonstrated by microscopy of stained tissue in certain other lesions of syphilis, notably parenchymal disease of the brain and in the lungs and liver of syphilitic newborn. In the pre-penicillin era, the lesions of tabes dorsalis were generally considered to represent the sterile end result of a previous involvement with *T. pallidum*. It came as a considerable surprise, therefore, to note clinical improvement in the so-called "lightning pains" of tabes dorsalis when afflicted patients were treated with penicillin. To be sure, evaluation of improvement in "lightning pains" is notoriously difficult, but long-experienced clinicians were convinced that penicillin influenced them. Thus an antimicrobial drug appears to exert its influence in lesions that hitherto were not considered to contain microbes. As noted above, however, the possibility remains that the lesions of tabes dorsalis represent an active syphilitic process, and it is merely our inability to cultivate *T. pallidum* that makes the situation seem at all unusual.

The lesions of rheumatic carditis are not gen-

erally believed to represent a direct tissue reaction to the presence of streptococci but some type of unusual host reaction to previous streptococcal infection elsewhere in the body. Moreover, on microscopic examination of the lesions of an acute rheumatic carditis, streptococci are not to be seen. Nevertheless, reports recur of the successful cultivation of streptococci from the acute lesions of acute rheumatic carditis in patients who have died during the acute stage of the disease (16-19). These reports have been made by knowledgeable people who have presented their findings with great diffidence. In today's climate of opinion, however, the general tendency with respect to the observations has simply been to look the other way. In experiments in rabbits, however, Denny and Thomas have shown that group A streptococci could persist in the tissues for many weeks and could then be evoked to the stage of bacteremia by the administration of cortisone (20). Whether, prior to evocation, they were dealing with a dormant or truly latent infection cannot be stated because the experiments were not designed for the specific study at this point.

Thus, with all due respect to the many more widespread beliefs concerning the relationships of *T. pallidum* to tabes dorsalis and streptococci to rheumatic fever, the possibility that these microbes in dormant or latent form are actually present in the respective lesions cannot be excluded.

Our Contemporary Challenge

What is the magnitude of the problem we face today with respect to this resurrection of infections from the inapparent state to the state of progressive disease? It is quite clear that the problem is a formidable one and by its very nature is bound to become even more so in the future. Indeed, it is not always appreciated that in the economically developed countries today it is these endogenous infections that constitute virtually the entire load of illness caused by all forms of microbial disease except those caused by viruses. In short, on an individual basis today, but on one that is bound to steadily widen, man is beginning to succumb to his own microbes.

All that is necessary to see this is to enter an adult ward of a general hospital any morning and inquire what problems are present that day with respect to infection. This is an experience that I happen to have every 6 weeks as part of our teaching program, and it is most illuminating. Certain points immediately become evident. First, a surprisingly important portion of the disease load on a general hospital ward on any one day is still caused by microbial infection. Second, no one microbial species or genus is particularly involved but rather the disease load is caused by a relatively wide assortment of microbes. Third, despite the heterogenicity, these disease-producing microbes have one outstanding characteristic in common: they all form what is customarily regarded as the normal microbial flora of man.

Thus the microbes causing the greater portion of our morbidity in hospitalized patients today are the familiar microbial species that through the years we have grown accustomed to regard without fear. On any one day the disease assortment will include infections produced by *E. coli*, *A. aerogenes*, *Proteus*, *Pseudomonas*, nonhemolytic streptococci, and *Monilia*. Two other microbes, staphylococci and tubercle bacilli, likewise deserve inclusion on the ground that although they are capable of producing disease they commonly inhabit our bodies without doing so. Approximately one-half of any group of adults are carriers of potentially pathogenic staphylococci. With tubercle bacilli the situation depends on one's age. It is estimated that 40 percent of the population of the United States over the age of 30 are harboring living tubercle bacilli so that in effect both tubercle bacilli and staphylococci can be considered to be part of man's normal microbial flora.

All of these microbes have the capacity to survive for long periods in man without causing either benefit or harm insofar as can be detected by today's methods. But when man's internal environment is suitably altered, as is so often the case today, all of these microbes have the capacity to arise and produce serious illness.

The ways whereby man's internal environment is subject to alteration today are familiar to us all and represent the unsought portion of the consequences of our great therapeutic

advances. In ever-enlarging measure these advances are making it possible for us to permit the survival of the socially desirable but biologically unfit. This sociobiological force is not limited in its impact to infancy and childhood but is operative to a considerable extent at all ages of life. As a consequence there are many more of us who consider ourselves to be in "good health" but who have some defect with respect to our ability to make our own adaptation to the microbes around us. The defect may be in our structure or in our experience.

Even those of us who were structurally sound to begin with and who have not been overly protected against life's microbial experiences may rapidly lose our veteran status if we have to give up certain of our tissues to the surgeons or of necessity must be saturated with certain hormones. When man's internal environment was modified by politically induced states of extreme deprivation, such as in a Nazi concentration camp, the disease produced was largely microbial and was caused by the more prominent of the microbes that inhabit man (21). When crudely comparable states of deprivation are produced today by long-continued corticosteroid administration, the results are the same. And, if we accompany the tissue deprivation by a drug-induced suppression of the more prominent microbes, we get disease by the less prominent microbes such as *Monilia*.

We have been relatively slow in recognizing the importance of this problem of endogenous infection today. One part of it we seem to have almost suddenly discovered, namely, the hospital infections due to staphylococci. But we are slow in recognizing that important as staphylococci are—and I have no desire to minimize their importance—they represent, nevertheless, only a part of what is a considerably larger contemporary problem. Indeed, in terms of serious or fatal microbial disease in our adult hospital services, the intestinal bacilli and the fungi are usually even greater offenders than staphylococci. We are also too prompt to attribute successful microbial survival in this drug-ridden world to the phenomenon of genotypic drug resistance. It is not so much that drug-resistant staphylococci or the drug-resist-

ant members of other microbial genera are not important today as it is that they represent only one of the many ways whereby microbes can successfully adapt to the changes around them. The serious illness and death due to microbial disease today are not chiefly a result of once-susceptible microbes that have now become drug resistant. Instead, to an increasing extent, these diseases are being caused by microbes that never were susceptible to our drugs but hitherto have managed to persist in an inconspicuous fashion in our tissues.

As we have seen, not only does man lack the power to create life but his ability to destroy it, at least at the microbial level, is sharply limited. To the extent that this means that microbial adaptability will continue to blunt our attempts at therapy and prophylaxis, the situation might be regarded as being somewhat gloomy. But to the extent that what holds for the microbes holds for us as well, any restriction on man's ability to exterminate life has its good side too.

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Antibiotic Use for Preserving Fish

The use of an antibiotic to aid in keeping fresh-caught fish in sound condition was authorized for the first time by the Food and Drug Administration in an order, effective April 21, 1959, which sets a safe limit on the amount that may remain on such food without harm to the consumer.

The order allows commercial fishermen to use the antibiotic, chlortetracycline, on fresh-caught whole, headed, and gutted fish, shucked scallops, and unpeeled shrimp. Its use is not permitted on processed seafood products, including fish cuts, steaks, and fillets, peeled shrimp, and shucked oysters. Chlortetracycline has been used on poultry since 1955 and extensive data on its safety are available.

The maximum amount that may remain on the seafood has been fixed at 5 parts per million. This quantity will not always be removed in cooking, but the agency has determined that it may be consumed without harm even by persons sensitive to antibiotics. Treated seafood products must be labeled to show that they contain the antibiotic and that it has a preservative effect.



Computers and Bicycles

Malaria surveillance field teams in Thailand expect to protect 5 million people each month in house-to-house visits. For this full-scale program, a report form for rapid analysis by electronic computers has been developed.

Village surveillance records are summarized for each canton, an administrative grouping of about 10 villages. The canton surveillance summary reports, about 1,000 a month, require analysis for location, population, control operations, workload, fever cases, treatment, and malaria by age groups.

A report from the northern region explained that the first cycle of the program will probably take 4 months to complete, because time is needed to improve the procedure and many employees are new to the work. Also the shortage of bicycles has meant that men must travel on foot over trails between scattered villages that cannot be reached by jeep. However, Thai officers and men treat the program as a personal challenge and are working enthusiastically to see it through.

—J. MILES BUTLER, Ph.D., *malaria eradication adviser, Chiangmai, U.S. Operations Mission, Thailand.*

The Pitha Turned Red

By the time we reached Tarabou, a village near Dacca, East Pakistan, to investigate a report of sudden fatal illnesses, 6 children had died and 8 other people had been ill. A 20-year-old woman had the same symptoms as the younger victims, cyanosis, restlessness, abdominal pain, and signs of circulatory collapse. We learned that the children, whose ages ranged from 1 to 6 years, had died within half an hour after they became ill. The others had recovered in 3 to 5 hours and had no apparent residual effects. A chemical poison seemed to be the most likely cause of the illnesses.

The detailed food histories showed that rice and

water were the only items consumed by all the people who were affected. The rice had been boiled and nothing had been added to it. We suspected the water which came from the river, and checked the alum used to clarify it. Then we discovered that the last family we interviewed drew water from a nearby pond and did not use alum.

Meanwhile a sanitarian, questioning the families independently, found that some of those who became ill had eaten a rice cake called pitha. We questioned all the families again; everyone who became ill had eaten pitha.

Analysis of the rice cake showed the salt ingredient contained sodium nitrite. We learned later that the woman who made the cake had asked a bus driver to get salt for her. He had a package of salt in the bus and handed it to her. She remembered, as she prepared pitha that day, that the rice cake turned red.

—MOHAMMED FAHIMUDDIN, M.D., *director of public health, East Pakistan, and* GLENN S. USHER, M.D., *special assistant for medical activities, Communicable Disease Center, Public Health Service, and co-leader, epidemic aid team to East Pakistan, May-July 1958.*

Rural Occupational Medicine

Occupational medicine and rural hygiene are combined in the research work carried on by the State Institute of Rural Occupational Medicine and Rural Hygiene in Lublin, Poland. Prof. Dr. Józef Parnas is director of the institute and Prof. Dr. F. Wysocka is its scientific secretary.

The institute's origins are connected to Prof. Dr. Witold Chodźko, Poland's first minister of health and a member of the sanitary organizations of the League of Nations, who helped to set up the nation's first health stations in 1905.

Since the institute was established in 1951, it has conducted laboratory and field research on the effects of chemicals on agricultural workers, the working conditions of drivers of farm machinery, rural housing, and the personal hygiene and prevalence of parasites in the rural population. It has dealt with outbreaks of tularemia, Q fever, leptospirosis, toxoplasmosis, and brucellosis; and has trained rural surgeons and workers for sanitary and epidemiological stations.

The newer phenolic and vinyl base paints present less of a health hazard from lead intoxication than oil base paint, according to this study which investigates the effect of a number of variables on lead solubility.

Laboratory Study of the Solubility of Red Lead Paint in Water

D. A. FRASER, M.S., and L. T. FAIRHALL, Ph.D.

CONCERN increases over the amount of lead taken into the body as it becomes more and more apparent from analyses of food, air, and water that each of these contributes a quantity of lead each day. The maximal non-cumulative daily body burden of lead has been determined to be approximately 0.5 mg. Lead intake from sources other than water approaches this permissible maximum. If it is found that any one of the three sources contributes an undue share of lead, efforts should be made to identify that source and suggest a remedy.

In view of the extensive industrial use of red lead and red lead paints and the hygienic significance of lead compounds, it is remarkable that so very little is known about the solubility of these materials in water. According to Friend (1), red lead is "practically insoluble in water." The only value we have found in

the literature is one theoretically derived by Glasstone (2) from electrode potential measurements. Glasstone measured the electrode potential of the half element $\text{Pt} \left[\begin{smallmatrix} \text{Pb}_3\text{O}_4 \\ \text{PbO} \end{smallmatrix} \right]$ against the standard mercury-mercurous oxide electrode using identical solutions of carbonate-free-N-sodium hydroxide throughout. The value obtained of -0.610 is very slightly higher than the theoretical potential of -0.617 volt. Assuming the ionization of red lead to be $\text{Pb}_3\text{O}_4 \rightleftharpoons 2 \text{Pb}^{++} + \text{PbO}_4^{--}$ the solubility of red lead in N-NaOH is 1.1×10^{-17} gram-mol per liter at 17°C .

Our study was undertaken to determine experimentally the solubility of red lead and the extent of dissolution of lead by water in contact with surfaces coated with red lead paint. Three types of red lead paint were tested: linseed oil base, phenolic base, and vinyl base. Specifications of these paints are given on p. 502. It should be noted that the oil base paint used did not contain the added litharge found in present-day specifications. Several lots of oil base paint, some ground commercially and some in the laboratory, were studied. In a supplementary experiment the three types of red lead paint were exposed to the solvating action of natural and treated waters from eight localities in the United States.

Since the data were obtained in the laboratory

Mr. Fraser, a chemist, is with the Occupational Health Branch, Division of Special Health Services, Public Health Service, at Field Headquarters in Cincinnati, Ohio. Dr. Fairhall, formerly with the branch, is deceased. Dr. Herbert E. Stokinger, chief toxicologist of the branch, and the staff of the Division of Sanitary Engineering Services provided many helpful suggestions in the critical review of the manuscript. (Manuscript received for publication February 9, 1959.)

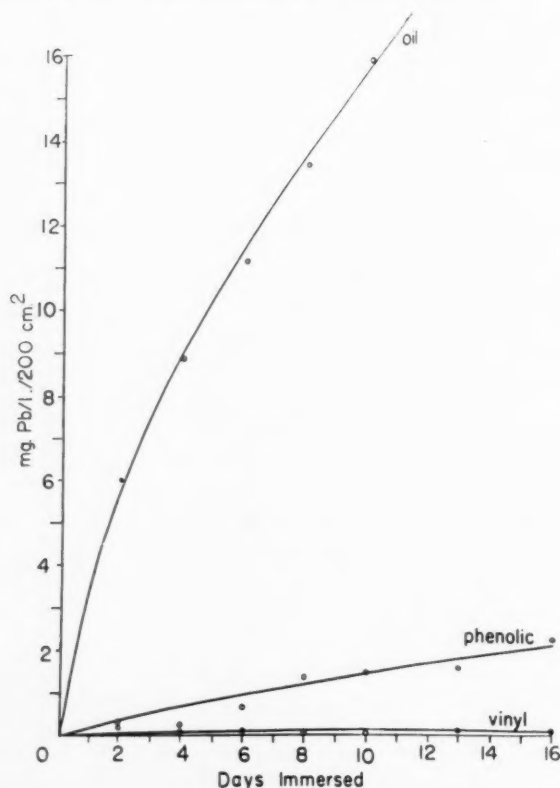
and selected variables affecting the solubility of lead were studied separately, the study does not apply to all variables, acting in combination, that may be encountered in the field. For a valid toxicological appraisal of the amounts of lead in water, samples taken from tanks actually in use with various types of water would have to be analyzed.

Red Lead Powder

The chemical procedures for determining the amount of lead taken up by water in contact with red lead may be interfered with by (a) the particle size of the red lead, (b) the colloidal tendency and penetration through filtering media, and (c) adsorption of lead by the filtering medium.

Measurements of the particle size of the samples of red lead powder showed an average of 0.8 micron (μ), with a range from 1.3μ to the lower limit of visibility of the optical micro-

Figure 1. Dissolution of lead from red lead paint in contact with distilled water.



NOTE: Drying time for oil base paint: 80 days.

Specifications and Formulas for Paints Tested

Oil Base

From Federal Standard Stock Catalog, Section IV, Part 5. Federal Specification for Paint; Red Lead Base, Ready Mixed, TT-P-86a (May 4, 1949), type I.

Component	Percent by weight
Red lead (Fed. Spec. TT-R-191, type I, grade C)-----	77.53
Aluminum stearate (Navy Spec. 52 A 12)-----	.23
Raw linseed oil (Fed. Spec. TT-O-369)-----	10.90
Pale heat-bodied linseed oil (Navy Spec. 52020)-----	3.78
Mineral spirits (Fed. Spec. TT-T-291, grade 1)-----	6.45
Liquid drier (Fed. Spec. TT-D-651, type I)-----	1.11
	100.00

Phenolic Base

From Federal Standard Stock Catalog, Section IV, Part 5: Federal Specification for Paint; Red Lead Base, Ready Mixed, TT-P-86a (May 4, 1949), type IV.

Component	Percent by weight
Red lead (TT-R-191, type I, grade C)-----	55.99
Magnesium silicate (TT-M-90)-----	4.36
Diatomaceous silica (52-MC-522, type I)---	5.25
Aluminum stearate (52 A 12)-----	.26
Phenolic varnish-----	25.35
Aromatic petroleum spirits (TT-N-97, type II)-----	7.60
Diptene (TT-D-376)-----	.94
Lead naphthenate (24 percent Pb)-----	.08
Cobalt naphthenate (6 percent Co)-----	.02
Manganese naphthenate (6 percent Mn)-----	.02
Antiskinning agent (National Aniline ASA)-----	.13
	100.00

Vinyl Base

No Federal specification available. Red lead vinyl resin paint, supplied by National Lead Co., Brooklyn, N.Y.

Component	Percent by weight
Red lead (TT-R-191, type I, grade C)-----	23.70
Aluminum stearate-----	.10
Vinyl resin—VAGH-----	16.35
Tricresyl phosphate-----	1.64
Toluene-----	25.31
Methyl isobutyl ketone-----	25.31
Carbitol (low gravity)-----	7.59
	100.00

scope, about 0.5μ . A suspension showed active Brownian movement, and the colloidal aggregates precluded filtration through even the best grade filter paper. A certain amount of colloidal lead invariably penetrated the filter, as shown by the Tyndall effect, with resultant erroneously high values.

The adsorption of lead on the filter paper causes erroneously low values. O'Shea (3), who first demonstrated the adsorption of lead by filter paper, showed that filtration of dilute lead acetate solution resulted in a loss of approximately 0.2 mg. of lead in 50 cc. of solution. Preliminary experiments in this study showed that filter paper adsorbed lead from neutral solution to such an extent that three filtrations of an optically clear solution of 1 mg. of lead salt per liter of water removed 99 percent of the lead.

Ordinary filtration procedure was therefore excluded, and pressure filtration through cellophane with the Zsigmondy type of apparatus was resorted to. When wettable cellophane, designated as 600-PUT-O, was used as the filtering medium under a pressure of 150 kg./cm.²

Figure 2. Effect of drying time on dissolution of lead from oil base red lead paint.

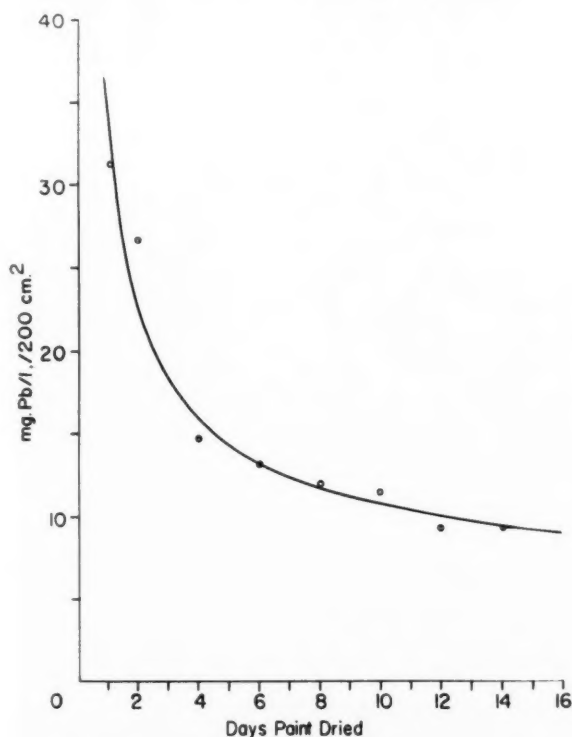
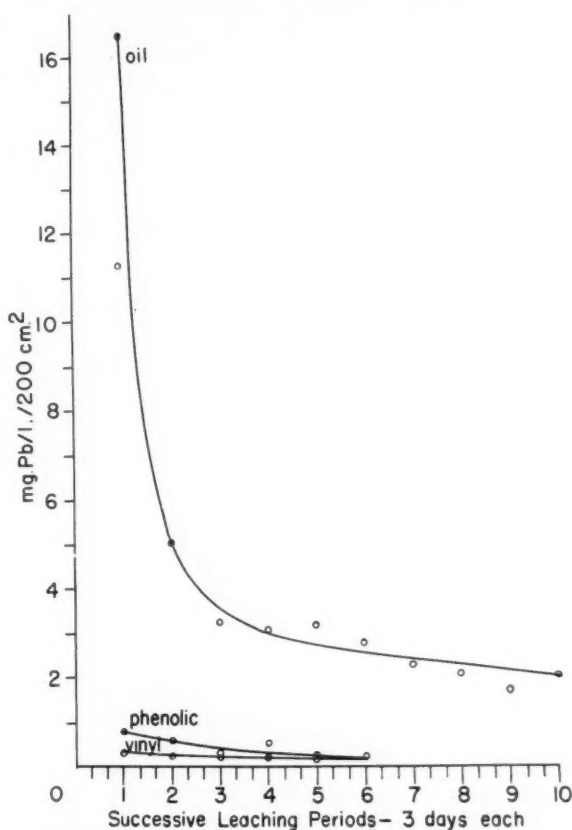


Figure 3. Effect of successive leaching of red lead paint film with water.



NOTE: Drying time for oil base paint: 10 days.

of nitrogen gas, no detectable lead loss occurred and the filtrates were optically clear.

Suspensions of red lead in distilled water were shaken in Pyrex bottles until equilibrium was reached. The lead content of the pressure-filtered solutions was determined by the chromate method of Fairhall and Keenan (4). This analytical method was chosen because, being a titration method, it is applicable over a wide range of concentrations without dilution of the sample or other extrapolation of results.

Because of probable contamination of red lead with the more soluble lead monoxide, reagent-quality red lead was purified by Glassstone's method by repeated treatment with sodium hydroxide (1), and then washed with dilute acetic acid. The successive portions were analyzed for lead until constant values were obtained.

Purified reagent grade red lead powder gave an average value in distilled water at room tem-

perature of 5.53×10^{-4} gram of lead per liter (0.553 ppm) or 8.9×10^{-7} gram-mol of Pb_3O_4 per liter. Suspensions of red lead in distilled water gave only a slightly greater amount of lead in true solution after standing for 1 year.

Red Lead Paint

The investigation of red lead paint was concerned solely with the lead in solution. Particulate lead oxide or particles of lead paint film resulting from blisters or pinholes and mechanically swept into suspension, while hygienically important, were completely removed, and the results in all cases refer only to lead in true solution.

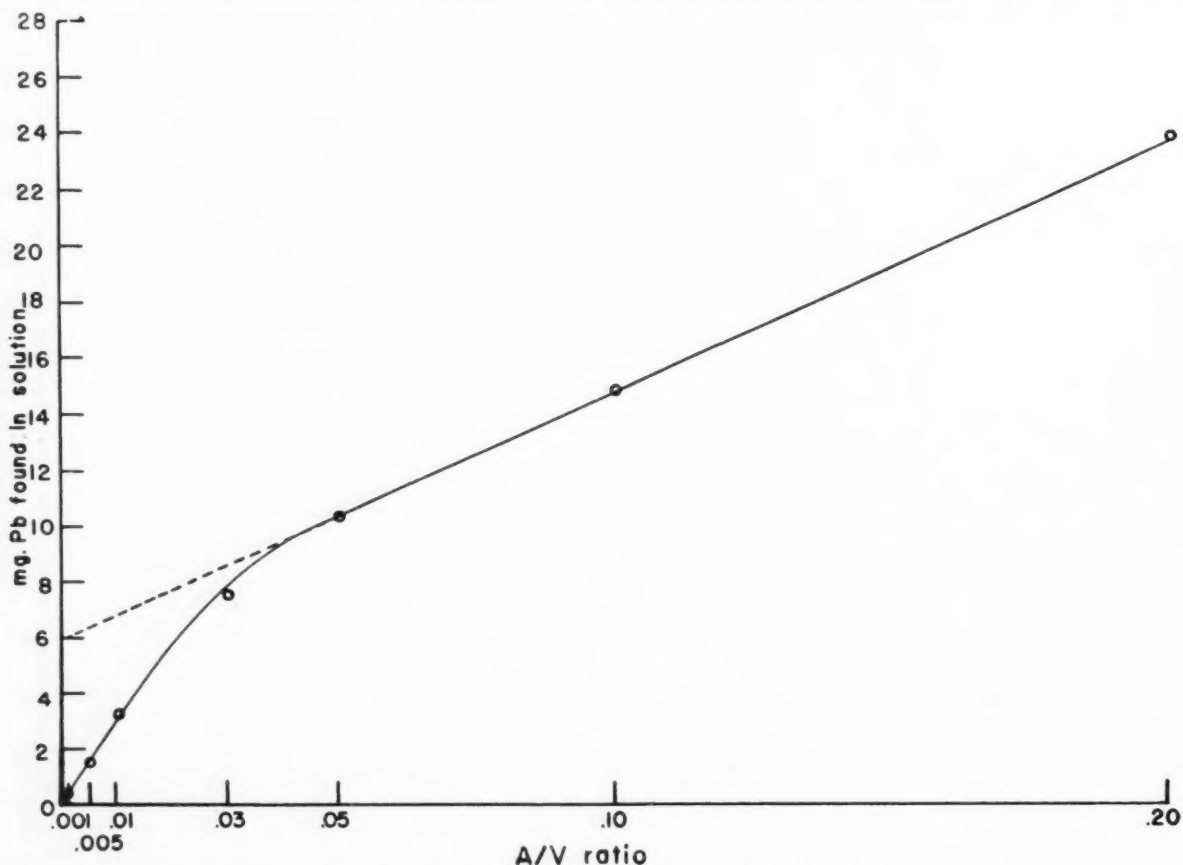
Although the effect of water alone was of primary interest, the effects on lead solubility of sodium hydroxide, sodium hexametaphosphate, free chlorine, and differences in alkalinity and acidity were also studied.

For most of the tests the paint was applied

to glass surfaces. Glass was used so that the results would reflect the solution tendency of the paint film itself rather than the effect of possible interaction of the paint film and metal surfaces. Several dozen glass plates were cut to measure 3 inches by 6 inches from stock 0.3 cm. thick. Areas of 100 cm.² were measured and marked off on each plate. The plates were washed, cleaned with nitric acid and distilled water, dried, and painted to the desired area, and the paint film was allowed to dry for appropriate periods. In studying the oil base paint, various drying times were tested. The drying time of the phenolic and vinyl base paints was less important, since drying consists principally in evaporation of the solvents (5).

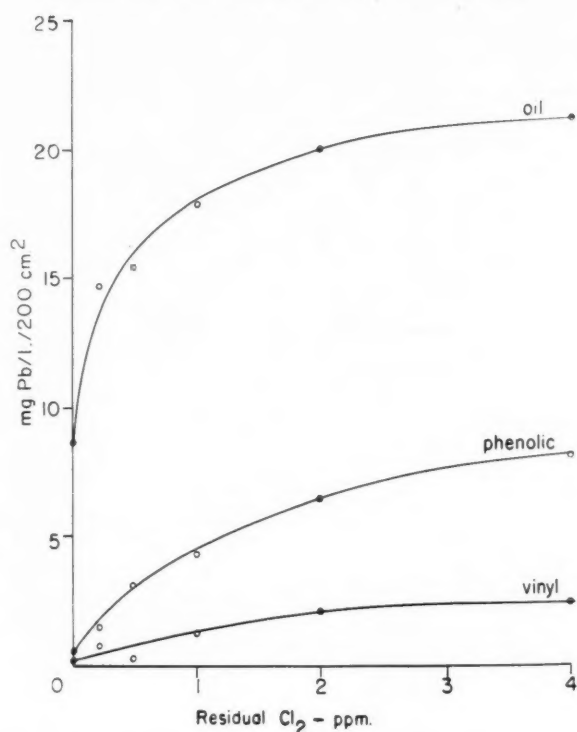
Water solubility tests were also made for lead from the three paints on black iron and on galvanized iron plates. The red lead paint was applied directly to the iron plates or over an undercoating of zinc-chromate primer.

Figure 4. The amount of lead in solution plotted against the area/volume ratio (cm.²/cm.³).



NOTE: Data for oil base paint, with drying time of 7 days and immersion time of 3 days.

Figure 5. Effect of chlorination of water on dissolution of lead from red lead paint.



NOTE: Drying time for oil base paint: 94 days. Immersion time: 3 days.

When the primer was used, the red lead paint was followed by a coat of aluminum paint.

The painted plates, both glass and metal, were placed in tall form 1-liter beakers, and 500 ml. of either distilled water or the desired salt solution was added. The beakers were sealed with sheet Parafilm and allowed to stand at room temperature for the desired time. The plates were then removed, rinsed with distilled water, and the water was analyzed for lead by the chromate method (4).

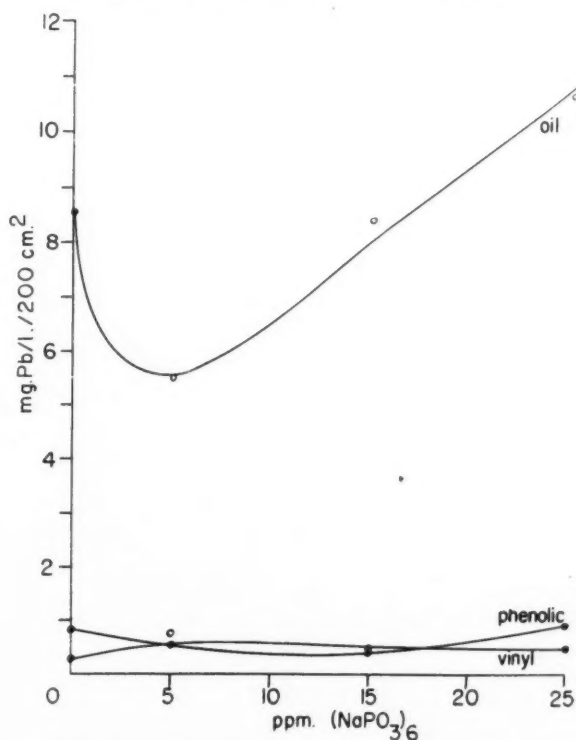
Finally, an experiment was performed in which successively smaller areas were painted with the oil base paint and dried for 7 days. These glass plates were immersed in successively greater volumes of water. After immersion for 30 days the water was drained off and tested for dissolved lead by the more sensitive dithizone method (6). This procedure permitted an investigation of the range of area/volume ratios from the experimentally determined ratios to those that might be encountered in the field.

In the supplementary investigation the three types of red lead paint were exposed to natural water. To determine the effect of variations in natural water on the solution of lead, samples of the treated city water supplies from eight localities in the United States were obtained. Areas measuring 100 cm.² on glass plates were painted with the red lead paint, and the plates were immersed in 500 ml. of each of the water samples for 30 days after the paint had dried for 7 days. The water was then analyzed for lead content by the chromate method (4).

The results of all experiments are expressed in milligrams of lead dissolved per liter of water for exposure surface of paint film of 200 cm.² In all experiments except the area/volume ratio study, the area/volume ratio was 100 cm.²/500 ml., or 1 cm.² of surface per 5 ml. of solution.

Immersion time. The results of the immersion-time experiment show clearly that the oil base paint yields increasing amounts of lead with continued exposure (fig. 1). After 10

Figure 6. Effect of sodium hexametaphosphate on dissolution of lead from red lead paint.



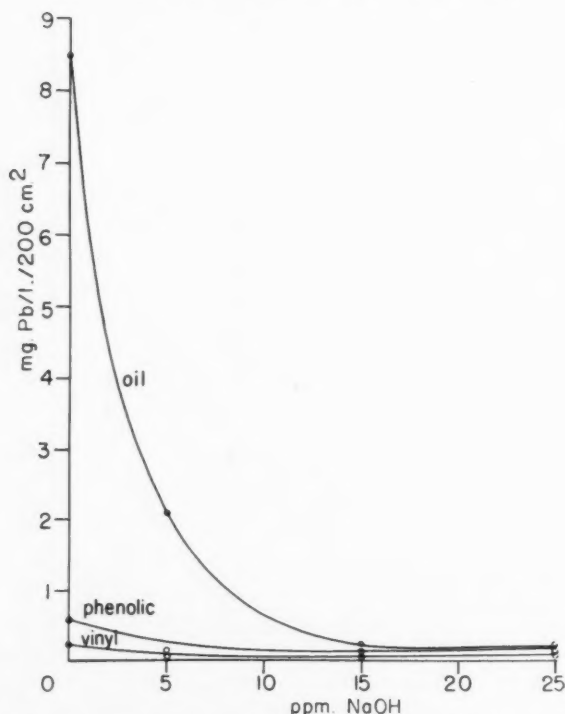
NOTE: Drying time for oil base paint: 97 days. Immersion time: 3 days.

days' immersion, the lead content of the test water was 15.8 mg. per liter. Furthermore, the oil base paint yields more lead in water than either of the other two paints. The highest value for the phenolic base paint was 2.32 mg. The highest for the vinyl base paint, which yielded the least amount of lead of any of the paints, was 0.13 mg.

Drying time. For the oil base paint, increasing the drying time from 1 day to 2 weeks appreciably decreased the release of lead, from 31.24 mg. to 9.30 mg. after 3 days' immersion time (fig. 2). Drying beyond the 2-week period caused a further slight reduction. However, an average value of 7.44 mg. per liter of water was obtained after 80 days of drying. Since the drying of the phenolic and vinyl paints consists largely in evaporation of solvent rather than the complicated chemical reactions which occur in the drying of linseed oil base lead paint, no particular change in the amount of lead in solution would be anticipated, and none was observed.

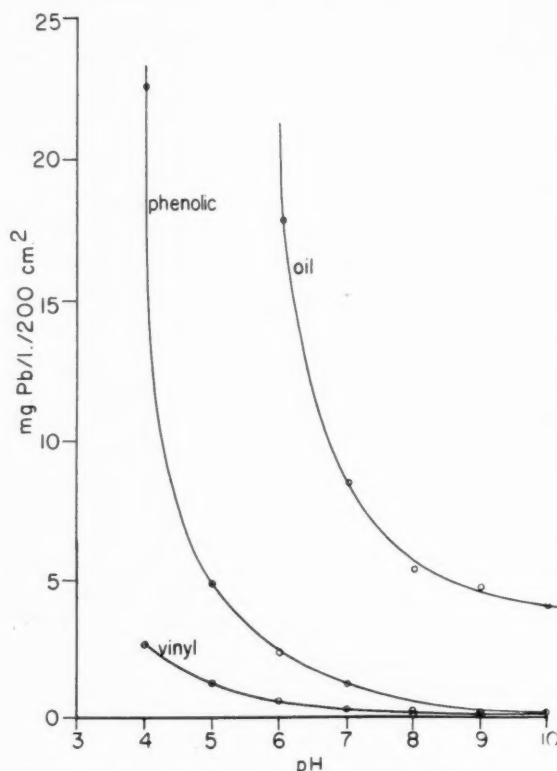
Repeated immersion. Repeated immersions,

Figure 7. Effect of sodium hydroxide on dissolution of lead from red lead paint.



NOTE: Drying time for oil base paint: 97 days. Immersion time: 3 days.

Figure 8. Effect of variation in hydrogen ion concentration on dissolution of lead from red lead paint.



NOTE: Drying time for oil base paint: 14 days. Immersion time: 3 days.

each lasting 3 days, resulted, for the oil base paint, in a decided decrease from the first high value of 16.50 mg. of lead per liter of water until a nearly constant value of 2 mg. was obtained after the 10th immersion (fig. 3). A slight decrease was also noted for the phenolic and vinyl paints, but the initial solubility was much less. The decrease was from 0.81 to 0.21 mg. of lead per liter with the former and from 0.28 to 0.19 mg. with the latter.

Area/volume ratio. As the area/volume ratio (cm^2/cm^3) decreases from 0.2 to 0.05, a straight line relationship holds (fig. 4). A further decrease results in values which lie considerably below those predicted by an extension of the straight portion of the curve.

Residual chlorine. Because public water supplies generally are chlorinated, the effect of residual chlorine on red lead was studied. With all three types of paint, lead solvency was increased by the presence of 0.0–0.2 ppm of

residual chlorine, the normal range of chlorination. With higher residual chlorine concentrations there was a further increase to a constant maximum. With the oil base paint the amount of lead dissolved in 3 days increased from a value of 8.54 mg. per liter per 200 cm.² in chlorine-free water to 14.54 mg. at a chlorine value of 0.2 ppm. Phenolic base paint under the same conditions increased from 0.59 to 1.62 mg., while vinyl base paint increased from 0.24 to 0.85 mg. (fig. 5).

Sodium hexametaphosphate. Addition to the water of low concentrations of sodium hexametaphosphate, another chemical often used in treating public water supplies, caused depression in the solubility of lead during an immersion period of 3 days (fig. 6). This effect has been noted previously by Ruchhoft and Kachmar (7) with reference to other lead salts. The solvent action of sodium hexametaphosphate was apparent only at relatively high concentrations (25 ppm). At the concentrations investigated this salt had little or no solvent effect on vinyl base red lead paint.

Sodium hydroxide. With increasing amounts of sodium hydroxide (up to 25 ppm) the amount of lead carried into solution decreased, for all three types of paint (fig. 7). With the oil base paint there was a decrease from 8.54 mg. after 3 days' immersion in distilled water to 0.23 mg. following immersion for the same period in water containing 25 ppm of NaOH.

Hydrogen-ion concentration. Variation in

pH from 4.0 to 10.0 indicated that water on the acid side of neutral has a greater solvent effect on paint film than does water on the alkaline side (fig. 8). Sodium acetate buffer with either acetic acid or sodium hydroxide was used to cover this entire range. The solution was made as weak as possible, consistent with obtaining buffering capacity, in order to limit the effect of the acetate ion and to record only the effect of the hydrogen-ion concentration. Immersion time was 3 days, and the oil base paint film was dried for 14 days prior to testing.

With all three paints, pronounced solubility of the red lead occurs at a pH of 4. The solubility value for oil base paint increased from 8.44 to 117.2 mg. per liter per 200 cm.² at this pH; for phenolic base paint it rose from 1.21 to 22.4 mg.; and for vinyl base paint, from 0.31 to 2.71 mg.

Nature of surface. Whereas most of the foregoing work was based on paint films on glass, further studies were made, as noted above, of red lead painted plates of black iron, galvanized iron, and iron plates with a priming coat of zinc chromate conditioner. When the iron plates were completely covered with red lead paint, the results were similar to those obtained with glass plates. The values were somewhat lower when the red lead paint blistered, formed pinholes, or became detached in any way so that the more basic metal was in contact with the solution. It was assumed that such decrease was due to the replacement of Pb ions by the metal higher in the E.M.F. series. Unpainted

Table 1. Characteristics of water in eight localities: Results of analyses supplied by local water departments

Locality	pH	Parts per million											
		Total solids	Na and K	HCO ₃	SO ₄	Cl	NO ₃	Hardness as CaCO ₃	Mg	Ca	Fe	SiO ₂	F
Amarillo, Tex.-----	7.90	400	29	326	36	14	2.7	263	39	41	0.02	70	3.7
El Paso, Tex.-----	8.20	634	162	24	265	121	.4	196	19	34	.06	13	.8
Jacksonville, Fla.---	7.95	384	13	150	150	20	.01	290	32	70	.06	23	(1)
Cleveland, Ohio.-----	7.60	159	5.6	113	25	11	(1)	120	8.4	35	.07	(1)	(1)
Boston, Mass.-----	6.65	28	3.2	7	6	2.1	.22	15	.7	3	.02	3.7	(1)
Catskill, N.Y.-----	7.30	28	1.7	11	8	1.0	.49	20	1.2	4.5	.04	2.6	(1)
Croton-on-the-Hudson, N.Y.-----	7.45	69	2.9	41	11	2.6	.88	51	4.2	12	.05	9.6	(1)
Seattle, Wash.-----	7.50	49	3.6	28	6	1.2	.2	21	1.4	6.7	.02	13	(1)

¹ Not reported.

iron plates placed in the same beaker with glass plates coated with oil base red lead paint caused a reduction in values for the glass plates of 3.4 mg. in a test period of 7 days.

Further experiments with unpainted iron plates in a very dilute solution of lead acetate caused a drop in concentration from 9.56 mg. to 1.31 mg. of lead per 500 cc. Plates painted with vinyl base paint followed by an overcoating of aluminum paint yielded as much as 0.114 mg. of lead per liter.

Water samples. For the tests of the effect of water from city supplies, samples were obtained from localities differing widely with regard to such factors as fluorides, hardness, total solids, and pH value. The normal water data given in table 1 are average results supplied by the water departments of the various cities and are not necessarily the exact mineral content of the samples used. All water samples were tested for lead by the dithizone method before use, and no lead was found.

In the experiment with oil base paint, the amount of lead found in solution after immersion for 30 days varied from 28.9 mg. per liter for water from Amarillo, Tex., to 3.62 mg. per liter for water from Seattle, Wash. The effect of the various types of water tested on the phenolic and vinyl base paints was equally variable (table 2).

Discussion

Whereas red lead purified by Glasstone's method gives somewhat lower values than those obtained with the commercial product, the value obtained by direct measurement is greater than the theoretical figure arrived at by electrode potential measurement. An explanation of the low results which Glasstone calculated from such measurements may exist in the fact that these measurements were made in N-NaOH (40,000 ppm). Our results show that sodium hydroxide decreases the solubility of red lead within the range investigated (fig. 7). It is possible that this may hold also for higher concentrations of sodium hydroxide.

Particularly interesting in our study are the results regarding the effect of pH and certain substances on the rate of dissolution of lead. Pertinent data are summarized in table 3.

Table 2. Dissolution of lead from red lead paint on glass plates immersed for 30 days in water from eight localities

Locality	Milligrams of lead per liter of water per 200 cm. ²		
	Oil base paint	Phenolic base paint	Vinyl base paint
Amarillo, Tex.-----	28.9	0.31	0.17
El Paso, Tex.-----	27.8	.27	.03
Jacksonville, Fla.-----	18.2	.11	.18
Cleveland, Ohio.-----	5.80	.31	.38
Boston, Mass.-----	5.54	1.30	1.09
Catskill, N.Y.-----	4.07	.53	.25
Croton-on-the-Hudson, N.Y.-----	3.62	.60	.15
Seattle, Wash.-----	3.62	.60	.58

They show clearly the increased rate of solution of lead during the test period in the presence of residual chlorine or at low pH.

It had been anticipated that the protective oxidized oil film, coating the particles of red lead and resulting from the drying of oil base paint, would tend to reduce the solvent action of water. Of outstanding interest, therefore, is the finding in this study of a greater amount of lead in solution following contact with red lead oil base paint in comparison with the amount resulting from red lead powder suspended in water. Thus, the theory that a protective film retards the solution of red lead is not tenable in this case.

Table 3. Solubility of red lead paint according to type of water

Type of water	Milligrams of lead per liter per 200 cm. ²		
	Oil base paint (14-day dry)	Phenolic base paint	Vinyl base paint
Distilled-----	7.4	0.3	0.2
pH 6-----	16.5	2.4	.6
pH 7-----	7.4	1.2	.3
pH 8-----	4.8	.1	.1
Cl ₂ (1 ppm)-----	17.5	4.0	.5
NaOH (5 ppm)-----	2.0	.2	.1
(NaPO ₃) ₆ (5 ppm)-----	5.5	.6	.8

NOTE: Drying times for oil base paint corrected for ease of comparison. Immersion time: 3 days.

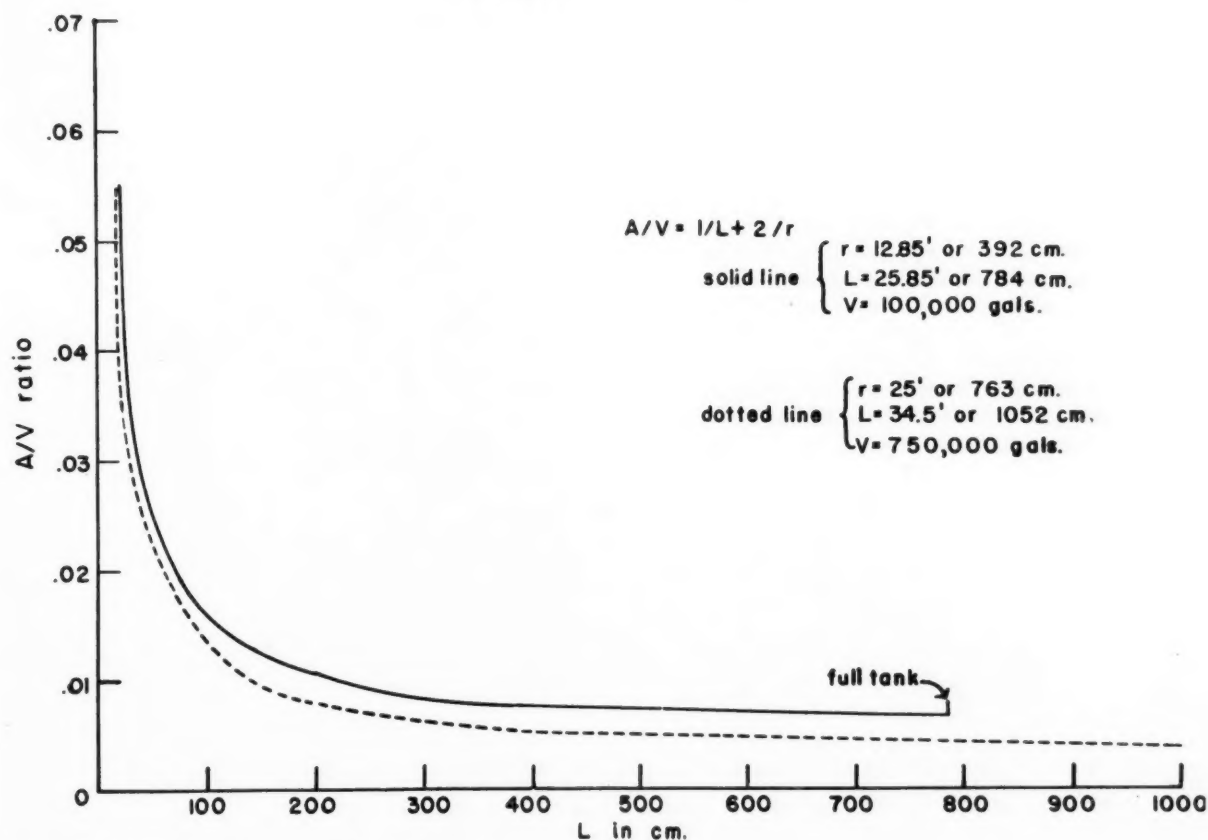
An explanation for this result is found in the effect of linseed oil on red lead itself. Red lead in contact with linseed oil results in the formation of either a small amount of lead soap, presumably lead linoleate, or a glyceride of lead (8-10). A preparation of the lead salt of the fatty acids of linseed oil exhibited solution properties similar to and values higher than the oil base film itself.

Although no figures for lead linoleate are given in the literature, values (calculated) for lead palmitate, lead myristate, lead stearate, and lead laurate (11) vary from 21.2 mg. of lead per liter of water to 46 mg. The value for the solubility of lead linoleate prepared from linseed oil used in the paint experiments in our investigation was 41.1 mg. of lead per liter of water. It is understandable, therefore, that appreciable amounts of the lead salt would leach out of this type of paint film in contact with water.

The effect of repeated leaching should provide a clue as to whether or not this was merely a surface effect yielding a relatively high initial concentration of lead, which tended to wash off and lessen in amount. The results obtained with the three types of paint exhibit such an effect. However, for the oil base paint the uptake of lead after 30 days of successive immersion approaches a nearly constant value of 2 mg. per liter per 200 cm.² of painted surface.

When the values shown in figure 3 are summed and compared with those of figure 1, it is found that, if the area of painted surface is kept constant while the volume of water is increased, the dissolution of lead from the paint surface is constant and independent of the volume. Therefore, the concentration of lead found in solution varies directly as the ratio of the area of paint to the volume of water. That this straight line relationship does not hold throughout the entire lower range of the area/

Figure 9. Area/volume ratios (cm.²/cm.³) attained in two cylindrical tanks of different dimensions as water level is increased.



NOTE: L=water height; r=tank radius.

volume ratio is shown by figure 4. The decrease in the amount of lead found at lower area/volume ratios may be due to the high initial solubility exhibited by the painted surfaces.

Figure 9 shows how the area/volume ratio changes with the water level in two cylindrical tanks the height of which is equal to the diameter. Comparison with figure 4 indicates that the values of lead concentration to be expected in normally operating public water supply tanks would be less than those determined experimentally with an area/volume ratio of 0.2.

Summary

The solubility of red lead powder and of lead from three types of red lead paint has been studied in a series of laboratory experiments. The effects of a number of variables were investigated separately.

The solubility of purified red lead in distilled water was found by analysis to be 8.9×10^{-7} gram-mol of Pb_3O_4 per liter (0.553 ppm) at room temperature.

The uptake of lead by water standing in contact with oil base red lead paint varies with the length of time of contact. In an immersion period of 6 days, 11.2 mg. of lead per liter per 200 cm.² of surface dissolved from oil base paint, 0.70 mg. from phenolic base paint, and 0.11 mg. from vinyl base paint.

The amount of lead dissolved by water in contact with oil base red lead paint varies inversely with the time of drying of the paint film.

Repeated immersion tests indicated that the leaching is partly a surface effect, and the dissolution of lead tends to approach a constant value.

Sodium hexametaphosphate causes a reduced rate of lead solvency in distilled water within the range of concentration of that used in treating public water supplies. At relatively high concentrations (greater than 15 ppm) there is an increased solubility of lead.

Sodium hydroxide up to 25 ppm depresses the rate of solution of lead with all three types of paint.

An increased hydrogen-ion concentration up to pH 4 causes a pronounced increase in the rate at which lead is dissolved from the oil base as well as the phenolic and vinyl base paints.

The nature of the material painted did not affect the lead solubility provided that no free metal was in contact with the water.

Results obtained with water samples from eight localities, differing widely in chemical characteristics, indicated that such characteristics have a profound effect on the rate of solution of red lead from paint film.

Of the three paints tested, the oil base paint was at least 10 times more soluble under the conditions of the test than either the phenolic or vinyl base paints.

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f luoridation

- 1** Statement by Arthur S. Flemming,
Secretary of Health, Education, and Welfare
- 2** Report on Fluoridation in the United States
- 3** Statements on Proposed Alternatives
to Fluoridation of Water Supplies

1 Statement by Secretary Flemming

Surgeon General Leroy E. Burney has called my attention to a very significant setback in the progress of the fluoridation program during the last 2 years.

Although controlled fluoridation has been proved over and over again to be an inexpensive and completely safe means of preventing

65 percent of dental decay, only one out of every four people in this country today has this protection.

Moreover—and this is the most disturbing fact of all—the proportion of the population not benefiting from this remarkable health measure is actually increasing.

Why every community with a public water supply has not availed itself of the proved dental health benefits of controlled fluoridation is difficult for me to understand in the light of the following facts:

1. Intensive research over a quarter of a century shows conclusively that water containing a proper amount of fluoride reduces dental decay by about 65 percent.

2. Equally conclusive research has demonstrated that controlled fluoridation is completely safe, causing no bodily harm of any kind.

3. The American Dental Association, the American Medical Association, and virtually all other scientific and professional organizations having competence in the field have recommended the fluoridation of public water supplies.

4. This protection costs only a few cents per person per year. If started in childhood, the protection is effective over a lifetime.

5. Controlled fluoridation does not mean adding a foreign substance to water; all water contains some fluoride. Fluoridation of water as a public health measure simply means controlling the amount of fluoride in a public water supply.

6. Even water containing as much as eight times the amount of fluoride recommended for prevention of tooth decay does not injure a person's health. Too much fluoride in water does cause discoloration of tooth enamel but has never been known to injure health.

7. Public opinion polls reveal that the majority of people who are informed about fluoridation are favorably disposed to the idea.

I have inquired into why, in the light of all these factors, the extension of fluoridation has been lagging in the last 2 years.

I have come to the conclusion that it amounts basically to this: the opponents of fluoridation are a militant minority; the proponents of fluoridation, as is so frequently the case with proponents of new health measures, are an un-militant majority.

In my review of the situation with Surgeon General Leroy E. Burney and his associates in

the Public Health Service, it seems to me that what is needed is a militant majority for fluoridation.

I am convinced that fluoridation would be proceeding rapidly if the question were decided on its merits by informed people.

Some informed people will, of course, continue to oppose fluoridation as a matter of principle. I respect their views even though I cannot, on the basis of the scientific evidence, concur in their conclusions.

But such persons are not, by and large, the ones who succeed in blocking local fluoridation projects.

For example, some of the most vocal opponents of fluoridation are persons who have been charged by the Food and Drug Administration with making false health claims for nostrums and devices and thereby influencing their customers against seeking needed medical service.

Dr. George F. Lull, then secretary and general manager of the American Medical Association, in an editorial in *Today's Health*, June 1955, used these words to describe the opposition to fluoridation:

"In addition to the sincere opposition which merits respect, there is the usual hue and cry from those who take every opportunity to discredit medical science and legitimate public health progress. We will find in the anti-fluoridation camp the antivaccinationists, the antivivisectionists, the cults and quacks of all descriptions, in short, everyone who has a grudge against legitimate scientific progress. They bring all manner of irresponsible charges, including the allegation that fluoridation is promoted for commercial profits by those who manufacture the chemicals and machinery and that irresponsible scientists and public officials have been 'bought.' The ridiculousness of such a charge evaporates into thin air when one merely looks at the official and professional bodies that have endorsed fluoridation."

As Dr. Lull implies, the kind of opposition to fluoridation which we are now experiencing is by no means new in the public health field. Indeed, this opposition is very similar to that which arose in the early days of such invaluable health measures as chlorination of public water

supplies, pasteurization of milk, and vaccination. Owing in large part to such opposition, it has taken 50 years, for example, to get widespread acceptance of chlorination. I hope that urban communities which have not yet fluoridated their water supply will not be denied this health benefit for a comparable period.

It is nothing short of tragic to deny millions of children the benefits, now and in their later years, of healthy teeth, particularly when, in addition to the scientific evidence that points to the efficacy of fluoridation, public opinion polls indicate that a majority of citizens desire to take advantage of this established health measure.

Yet this is clearly what is happening in a

number of communities large and small. For example, a poll by Elmo Roper and associates in 1957 showed that 57 percent of the people in cities of 1 million and over said fluoridation was a good idea, while only 20 percent said it was not. In communities of 100,000 to 1 million the response was 50 percent for and 19 percent opposed, while in communities of 2,500 to 100,000 it was 54 percent for and 24 percent against.

As long ago as 1953, when fluoridation was still relatively new and before the opposition became fully organized, a poll by Dr. George Gallup showed that people who knew about fluoridation favored its adoption as a community health measure by a margin of nearly four to one.

2

Report on Fluoridation in the United States

Dental decay is recognized as man's most widespread chronic disease. Few persons escape. No social stratum or age group is immune. A decayed tooth never heals by itself, by prescription, or by advice. About 97 million people in the United States have decayed teeth requiring treatment; more than 21 million others are edentulous; the average high school graduate has had 10 teeth attacked; and family dental bills total \$1.7 billion annually although only 40 percent get treatment. If everyone who needed dental care wanted it, there would not be enough dentists to provide it. The current progressive accumulation of dental disease is a heavy national burden—painful, costly, and disfiguring. This serious health problem remains largely neglected because of the undramatic nature of the disease, cost of treatment, the widespread tendency not to regard dental decay as a hazard, and insufficient professional manpower to provide care. This combination of factors points to the need for a preventive measure that is effective, safe, in-

expensive, convenient, widely acceptable, and automatic. The fluoridation of community water supplies meets these requirements.

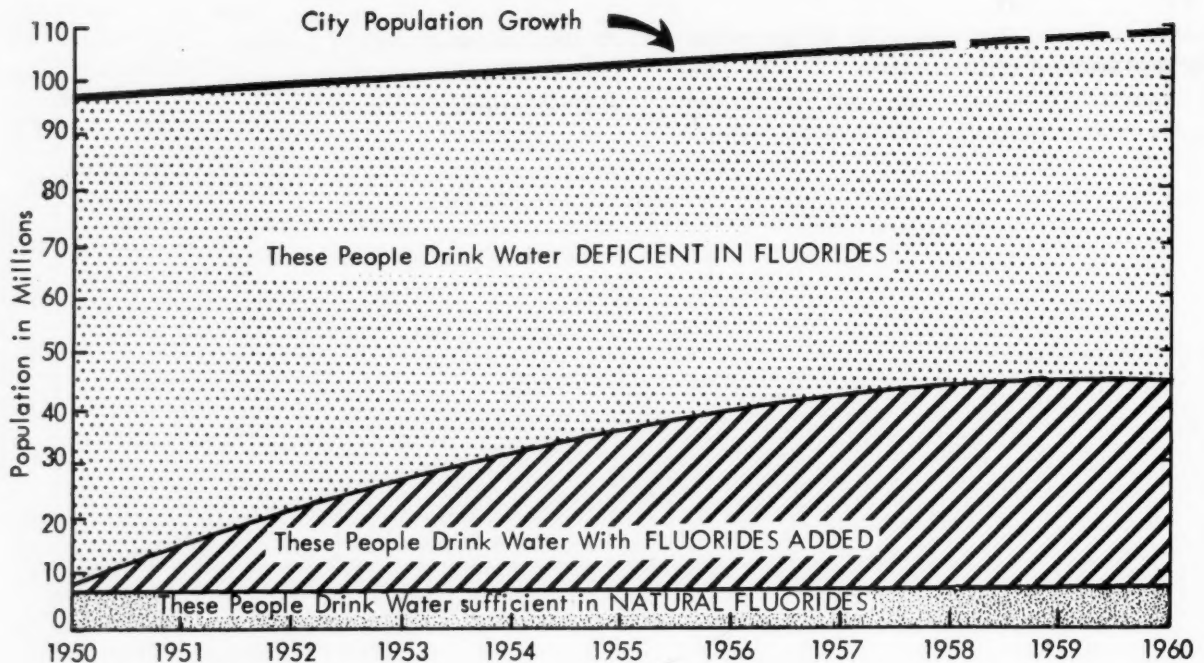
Fluoridation is the adjustment of fluoride-deficient communal water supplies to the optimal level by adding small, but precise amounts of fluoride-containing compound to yield in solution one part of fluoride in every million parts of water. In effect, it supplements the daily ingestion of fluoride to a level which effectively and safely prevents up to 65 percent of the dental decay among children, and provides protection and benefits that continue into adult life. In principle, water fluoridation is similar to standardized water-treatment procedures designed to promote the health of consumers.

Research

The early history of the fluorine and dental decay relationship goes back to the last quarter of the 19th century, when clinicians noted that less tooth decay accompanied mottled enamel. In 1916, Dr. Frederick McKay reported mottled enamel to be a waterborne disease, which in 1931 was discovered to be caused by excessive fluorides. A hypothesis evolved that trace amounts

*Prepared by the Division of Dental Public Health,
Bureau of State Services, Public Health Service.*

Urban Growth and the Fluoridation Lag



of fluoride in water might inhibit dental caries. A series of epidemiological studies was carried out by the Public Health Service led by Dr. Trendley Dean and his associates. They found a strikingly low prevalence of dental decay associated with 1 ppm fluoride in the drinking water. These studies in natural fluoride areas were confirmed by animal experimentation in laboratories and by independent scientists in other countries.

In light of the evidence that no undesirable effects accompanied the dental benefits derived from water supplies naturally containing 1 ppm fluoride, three controlled fluoridation programs were begun independently in 1945 to determine whether these benefits could be duplicated by controlled fluoridation. The results of these and other studies were remarkably uniform and demonstrated that the use of drinking water containing 1 ppm fluoride: (a) produces identical dental and general effects whether the fluoride occurs naturally or is added by mechanical means; (b) effectively, safely, and economically prevents up to 65 percent of tooth decay; and (c) does not produce observable mottling of the teeth.

Although alternative techniques and vehicles have continued to be tested, none of them to

date can substitute for fluoridation as a public health measure. (See statement on proposed alternatives, p. 517.) In the absence of water fluoridation or, where water fluoridation cannot be practiced, direct application of topical fluorides to the teeth has been found to reduce caries. However, the cost in professional time is rather high and limits this method on a large-scale public health basis.

Endorsements

After a thorough examination of all scientific evidence relating to the safety, effectiveness, and practicability of fluoridation, the Public Health Service endorsed it in 1951. Since that time many communities throughout the Nation have instituted fluoridation programs. Careful study of their experience with this measure plus continuing scientific research have provided additional evidence supporting fluoridation. The literature about the relation of fluorides to health now exceeds 8,500 references.

In this country fluoridation is approved by every major scientific and professional organization having competence in the field. It has also been approved by the World Health Or-

ganization, by professional and scientific associations in many foreign countries, and by responsible health officials throughout the world.

Present Status

Today more than 42 million people in the United States (or about 1 in every 3 persons provided water by community water supplies) are drinking water containing the minimum or higher level of fluoride recommended. Of these, 35 million in 1,778 communities are supplied water in which the fluoride level is controlled, and 7 million in 1,903 places use water naturally containing 0.7 ppm or more fluoride. Since 1950, the number of persons provided with fluoridated water in this country has increased by about 34 million. Fluoridation programs are also in operation in 20 foreign countries.

Water engineers report that the addition of fluorides to public water supplies is similar to chlorination and other procedures widely employed in waterworks practice. Fluoridation presents no administrative, technical, or industrial problems of any consequence. Presently, five fluoride compounds are used: sodium fluoride, sodium silicofluoride, hydrofluosilicic acid, ammonium silicofluorides, and fluorspar. Costs of fluoridation vary according to the amount and kind of compound required, but the average cost is 10 cents a year per person. A device developed by Public Health Service engineers now enables communities to use fluorspar, further reducing the costs by two-thirds.

Current investigations by the Public Health Service related to fluoridation include continuing evaluation of community water fluoridation programs; improving technical, control, and testing procedures; developing individual fluoridators for homes and schools in rural areas; testing various fluorides for a more effective agent to be applied topically to the teeth; and developing practical methods for removing excessive fluorides from water supplies.

Decline in Community Acceptance

At first glance, the acceptance of fluoridation during the last 8 years appears satisfactory.

A closer look, however, reveals that most of the gain has been made in the larger cities. Sixty-six percent of the Nation's cities with populations of more than a half million, and 32 percent of the cities with populations between 10,000 and 500,000 have fluoridation programs. By contrast, only 17 percent of those communities having populations of 2,500 to 10,000 and 5 percent of communities with populations of less than 2,500 have such programs. Consequently, most of the people benefiting from this measure live in the larger cities.

Of special concern is the steady decline in the rate of community acceptance in the past 6 years. Community acceptance proceeded slowly from 1945 to 1950, the early years of the demonstration studies. By 1952, however, most scientific and professional groups had examined the evidence and formally approved water fluoridation. That same year 243 communities instituted fluoridation programs. The following year, 1953, was the peak year during which 378 separate communities adopted fluoridation. Since 1953 the number of separate communities starting fluoridation programs has declined. Only 145 places began fluoridation programs in 1958. Moreover, the number of communities which discontinued fluoridation programs in the past 5 years has steadily increased.

The question may well be raised as to why this slow rate of acceptance has occurred, and what steps need to be taken to accelerate the utilization of this measure for the improvement of our Nation's health. Obviously, the big job is yet to be done.

There are two circumstances which explain the initial acceleration and subsequent slowdown in community acceptance of fluoridation. During the earlier years (1945-52) fluoridation was instituted by governing bodies that were convinced by the weight of scientific evidence. Only occasional objections were voiced against the measure. By late 1952, however, the formerly disorganized and sporadic opponents joined forces, forming two national organizations specifically to oppose fluoridation. As a result, the opponents obtained substantial resources; and, by employing a wide variety of tactics, they have been able to thwart the institution of fluoridation.

The other circumstance may be that the com-

munities which normally accept new health measures readily had done so by late 1952. Thereafter the rate of acceptance may have declined somewhat because it is more difficult to get acceptance by the remaining communities.

Organized Opposition

Four different groups oppose fluoridation—those who oppose it on principle; those in whom the measure arouses personal anxieties; those who acquire status, political gain, or personal profit; and those who are uninformed. Opponents, mostly laymen, but also including a few scientists, physicians, and dentists, carry on a nationwide campaign through their two national organizations in the United States.

It is quite evident that a relatively few people can create doubt and fear in many others who otherwise would accept the advice of competent experts. Antifluoridationists publish a monthly newspaper and submit articles to medical journals, popular magazines with national circulations, and newspapers. A book, "The American Fluoridation Experiment," has become the opposition textbook and is widely distributed. Opponents have delayed fluoridation by numerous injunctions. They have filed suits unsuccessfully in more than a dozen State courts. Two cases were even appealed to the U.S. Supreme Court where they were dismissed. Opponents send a steady flow of letters and literature to Federal, State, and local officials. As one after another irresponsible claim is refuted, opponents change their attack. Local merchants and editors frequently are intimidated by threats and harassing telephone calls. Proponents are abused by smear tactics and public heckling, and they and their families are threatened with physical harm. It is noteworthy that opposition in many communities comes in the first instance, not from residents of the city considering fluoridation, but from elsewhere.

Objections to fluoridation, however unfounded or unrealistic, strike a sympathetic chord in a sizable number of people. Continuous sensational assertions of an emotional type have far more effect on public opinion than the precise correct statements of scientists. Furthermore, some people, once persuaded to op-

pose something they do not understand, seldom change their attitude.

From coast to coast, numerous strife-torn communities, confused and divided over a word that was not even in their vocabulary a generation ago, can attest to the effectiveness of the antifluoridation campaign. The referendum is a particularly effective framework in which to oppose fluoridation. Irresponsible statements, misleading and horrifying, have succeeded in defeating fluoridation by referendums in Seattle, Wash., San Diego, Calif., Birmingham, Ala., Columbus, Ohio, and well over 230 other communities. By referendums, twice as many communities have rejected fluoridation as have adopted it.

Several factors contribute to the problem. Tooth decay is not a dramatic, infectious, crippling, or killing disease. Most people have learned to live with their dental problems and do not regard them as sufficiently serious to require treatment. The scientific arguments for fluoridation are not simple; fluoridation cannot compare with the drama of the wonder drugs, and the benefits to be derived from it cannot be observed for more than a decade—even then they are not obvious.

Viewed in historical perspective, the opposition to fluoridation has been quite similar to that which arose when other public health measures were introduced, particularly chlorination, pasteurization, immunization, and vaccination. The psychological bases for objecting to fluoridation are the same: (a) fear of being physiologically injured by a potentially noxious agent; (b) ethical aspects, with special concerns about invasion of human rights; (c) rejection of a new discovery that conflicts with entrenched beliefs; and (d) resistance to change.

The crux of the problem is that a relatively few people are blocking the progress of an approved health measure. By so doing they are not only withholding health benefits from a large portion of the population, especially children, but they are perpetuating a disease that seriously impairs the Nation's health, manpower, and economic resources. If dental decay were a direct cause of death, there would be little doubt of the widespread adoption of water fluoridation.

3

Statements on Proposed Alternatives to Fluoridation of Water Supplies

Tablets

"An extensive program has been instituted in Switzerland (1) in an attempt to control dental caries through the administration of fluoride tablets to school children. Held and Piquet (2) in a preliminary report of a study of 6-year-old school children, which continued 3 years, reported that compressed sodium fluoride tablets were effective in reducing the incidence of dental caries. With the report of positive results, the practice has spread rapidly, and approximately 500 Swiss communities are using this method of caries prevention (1). Apparently the tablets are distributed in the primary schools; the method of administration, if any, of the fluorine prophylaxis to preschool children and infants is not known. A recent communication from H. J. Schmidt indicates that prophylaxis by means of fluoride tablets is also being administered in the state of Hesse, Germany.

"Use of fluoride tablets has been limited in the United States. Dietz (3) has reported a study involving a small number of children. Positive results were reported. Bibby, Wilkins, and Witol (4) state that the use of fluoride lozenges may contribute to the control of dental caries, and that the effects are probably the result of fluorine acting on external surfaces of the teeth. The number of persons observed was relatively small and the duration of the study only 12 to 14 months.

"In discussing the question of using fluoride tablets beginning at 5 or 6 years of age (first school year), certain presumptive evidence from fluoridation studies might be kept in mind. From the behavior of the results that A. L. Russell (personal communication, 1955) is obtaining in his studies in Montgomery and Prince Georges Counties, Md., the ingestion of fluorides after the period of tooth formation may not give the same protective effect as ingestion during the period of calcification. Effects observed in the earlier fluoridation

studies support this inference; for example, the present dental caries prevalence rates in the Grand Rapids children who were 6 years old when fluoridation started (now 16 years old) as compared to those of the 16-year-old, Aurora, Ill., children who have used fluoride water all during their lifetime. It would seem logical, in the light of present evidence, to assume that an appreciable measure of protection would be lost if fluoride tablets were used by children only after starting to school, even if fluoride tablets are theoretically as effective as fluoride-bearing water.

"Another point to be borne in mind is that from the standpoint of effective public health application, the individual administration of fluoride tablets presents more difficulties than a broad community action, such as fluoridation. As a large portion of a child's permanent teeth are calcified prior to 6 years of age (normal time to enter primary school), a high degree of intelligent participation on the part of each mother, an alertness against waning interest, and a daily constancy of purpose measurable in years, is essential. The health education question posed by the tablet method of application becomes highly important if any degree of success is to be attained.

"In the light of present available evidence, prophylaxis by means of fluoride tablets cannot be evaluated properly until carefully controlled studies, including adequate numbers of children and observed over the necessary number of years, are available. At the present time, such studies are not available. From the standpoint of theoretical physiology, there would seem no reason why fluoride tablets should not be effective, providing some method can be found to ensure their conscientious daily consumption, at least over the period of tooth calcification. Because of the health education essential for their success it might be well, for the present, to limit the use of fluoride tablets in the control of dental caries to prescription by the dentist.

When all considerations are weighed, it would seem that in a community having a public water supply, the most economical and efficient manner of applying the fluorine prophylaxis to the greatest number of people is through fluoridation of the domestic water."

—H. Trendley Dean. *Fluorine in the control of dental caries. Journal of the American Dental Association, vol. 52, January 1956, pp. 7-8.*

"The preparation of fluoridated water at home by adding fluoride tablets to tapwater would be less expensive than the purchase of bottled water, but much more costly than communally fluoridated water. However, the proper preparation of such water in the home presents a very difficult problem of regulation. The problem is not merely one of assuring the addition of the proper amount of fluoride but also of proper mixing of the solution. An additional disadvantage of both alternative water procedures is that of inconvenience. It would be difficult to induce a high proportion of housewives and certainly of children to get their drinking and cooking water from a bottle rather than from the convenient sink tap.

"The daily consumption of tablets likewise raises questions of effectiveness and practicality. In the hands of trained personnel at the water treatment plant fluoride levels can be precisely controlled. But experience with other home remedies—even the aspirin tablet—prompts caution. The philosophy that 'if one tablet is good, two are better' may produce harm. A child's accidental ingestion of a large number of tablets is a great hazard from the viewpoint of those familiar with accidents in the home."

—From *Report to the Mayor on Fluoridation for New York City, by the Board of Health, City of New York, October 24, 1955, pp. 33-34.*

Bottled Water

"The process of preparing fluoridated water to be distributed in the same manner as bottled water involves the installation of equipment in one or more bottling plants and distribution to those who are willing to buy it. It is unlikely that a bottling plant would install the same kind of equipment that would be used in water treatment. One method that might be used is

that of dissolving tablets containing fluoride ion in the water. A number of technical problems are introduced. The water would have to be tested for fluoride ion by the health department and bottled water companies would have to employ technical staff to supervise treatment procedures.

"Persons using the water must pay for the water as well as the fluoride ion. It is estimated that bottled fluoride water would cost 5 cents per day per person using it, or about \$18.25 per year per person.

"Minimum health department supervision of bottled water fluoridation is estimated at \$20,000 per year. The minimum estimate of the cost of bottled fluoride water at present prices would be not less than \$18.25 per person per year. Such a price is of course prohibitive, and it is doubtful if many adults or children would have the benefit of fluoride water if such a fluoridation program were instituted."

—From *Report to the Mayor on Fluoridation for New York City, by the Board of Health, New York City, October 24, 1955, p. 37.*

Milk

"The Public Health Service does not favor the addition of fluorides to milk for the purpose of prevention of dental caries. The reasons for this position are as follows:

1. It is not known whether the addition of fluorides to milk is effective in preventing tooth decay, although it is known that such addition is effective in water. Further studies of this matter are indicated.

2. The individual consumption of milk by children varies considerably more than their water intake. For economic and other reasons, a considerable number of children in some age groups consume little or no milk. Furthermore, the use of fluorides in milk has not been investigated. On the other hand, we do know, on the basis of examination of many thousands of children who have consumed water varying in fluoride concentration, the amount of fluorides which must be added to water to be effective.

3. The possibility that fluoridation of milk may be harmful in an area where the water

supply is fluoridated or already contains sufficient fluorides.

4. The practical difficulties and hazards that would exist, both in controlling the rate of application and in testing the amount of fluorides added to relatively small volumes of milk by the large number of individual milk plants that might adopt this practice. From an administrative standpoint, the fluoridation of milk would spread the responsibility for control, and would necessitate the introduction of a complicated system of supervision.

5. The likelihood that only a portion of the milk supply would be fluoridated in a given market, resulting in a lack of uniform distribution. This would reduce the benefits to be obtained by the community as a whole. From this point of view, it would appear that water is a much better vehicle."

—*U.S. Public Health Service. The fluoridation of milk—a statement of policy.*

"Technical problems are such that representatives of the milk industry have resisted the idea of fluoridating milk in the past. It has been estimated that fluoridation will add 1 cent per quart to the milk price. Health department supervision of milk fluoridation would be costly. To provide adequate checking, 25,000 samples per year would need to be tested in the laboratory. The health department would have to construct adequate facilities for the testing program and enlarge the staff to perform the work. It is estimated that the annual cost exclusive of facilities would be \$294,800 for performance of tests by official methods of analysis. The cost of fluoridated milk for school children only in New York City is estimated at \$2,140,000, or \$2.14 per person."

—*From Report to the Mayor on Fluoridation for New York City, by the Board of Health, City of New York, October 24, 1955, p. 38.*

"In regard to the distribution [of fluoridated milk], the committee feels that there would be a lack of uniformity of intake in various parts of the country and that small farms and dairies in rural districts would have problems in controlling the addition of fluoride to small quantities of milk. Furthermore, the intake of milk during the first year of life would depend on

the extent to which the babies were breast fed. Human milk contains only traces of fluoride, the highest concentration found in our study (Hodge and associates, unpublished data) being 0.09 ppm."

—*The problem of providing optimum fluoride intake for prevention of dental caries. National Academy of Sciences-National Research Council, Publication 294, November 1953, p. 12.*

Bread

"Common foods suitable as carriers for fluoride, must above all meet the requirements of food technology for easy handling and mixing. Flour, as an example, may be considered a feasible vehicle from the standpoint of stability and the technology of distribution of the fluoride uniformly throughout the food. According to the study of Widdowson, the consumption of cereal increased from approximately 2 ounces per individual per day in the 1-year-old group to an average of 6 ounces in the 12-year-old. The consumption of bread showed roughly the same quantitative increase with age. Consequently, the average intake of fluoride, if added to flour, bread, or cereal, would come near to the desired increase with age from infancy to adolescence. The average daily consumption of flour in this country is estimated to be similar, or about 6½ ounces per individual per day in the adult. Considering the desirable intake of fluoride in older children as 1 mg. per day, the approximate amount of fluoride to be incorporated in the flour could be calculated. However, we have already referred to English observations suggesting that there are marked individual variations within single age groups in the consumption of bread. In addition, it is believed, for lack of exact data, that in the United States bread would not be used to a great extent in infancy during the early stage of tooth development."

—*The problem of providing optimum fluoride intake for prevention of dental caries. National Academy of Sciences-National Research Council, Publication 294, November 1953, p. 11.*

Salt

"No exact information has been obtained with regard to the consumption of salt in various age

groups. It is not even certain that this vehicle would be practical from a technical standpoint; it would have to be determined, for instance, whether the addition of sodium fluoride would be uniform throughout and whether it would affect unfavorably the anti-hygroscopic property of the product. While the daily consumption would have to be determined more exactly, there are doubts as to whether this vehicle would serve the purpose for infants and young children."

—*The problem of providing optimum fluoride intake for prevention of dental caries. National Academy of Sciences-National Research Council, Publication 294, November 1953, p. 12.*

Summarization

"Various vehicles have been proposed for the systemic administration of fluoride in regions where water fluoridation cannot be applied. The most important of these vehicles seem to be milk, table salt, and fluoride tablets which are now all being tested. Milk might be a possible alternative vehicle in countries with a universal milk consumption by the children, while salt might be possible for regions with a low or irregular milk consumption.

"At present, the value of milk and salt for fluoride administration cannot be compared with that of drinking water, since the evidence in favor of the first two vehicles is incomplete; in particular, there is a total lack of clinical

evidence of their effectiveness. On the other hand, tablets have been shown to have some positive effect, although the experiments with tablets have been performed for a much shorter time and on a much smaller scale than drinking water fluoridation.

"Continued research on these fluoridation methods should be encouraged. If their effectiveness, practicability, and safety of application can be satisfactorily demonstrated, they may become very valuable in regions where water fluoridation is impossible."

—*Expert Committee on Water Fluoridation, First Report. World Health Organization Technical Report Series No. 146, Geneva 1958, p. 19.*

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Drinking Water Standards To Be Revised

An advisory committee of physicians, scientists, engineers, and administrators has been appointed to consider revision of the Public Health Service Drinking Water Standards. At its first meeting, March 24-25, 1959, special attention was given to limits for nonliving contaminants such as radionuclides and synthetic organics.

The Drinking Water Standards, first formulated 45 years ago and last revised in 1946, were originally applicable only to water used on interstate carriers. This is still their only legal basis. However, State health departments, the American Water Works Association, and the Armed Forces have accepted them as standards for public water supplies.

STATEMENT

*By Arthur S. Flemming, Secretary of Health,
Education, and Welfare, April 7, 1959*

Indian Health

ONE of the Nation's most dramatic health stories of our time has been unfolding quietly and steadily among American Indians and Alaska natives.

I have received from Surgeon General Leroy E. Burney a report of recent progress in the Indian health program covering improvements in health and medical services to the 385,000 American Indian and Alaska native beneficiaries. This report traces health trends since 1954, immediately prior to the transfer of the program to the Public Health Service in 1955, through facts and figures available in the closing quarter of 1958. Here are some of the highlights:

- Tuberculosis, once the leading cause of death among Indians and Alaska natives, dropped a full 40 percent among the Indians in the 4-year period ended with 1957. Among Alaska natives, the decrease was even greater—63 percent in the same period. This disease now ranks as the eighth cause of death among Indians, and fifth among Alaska natives.

- New cases of tuberculosis have dropped 25 percent among Indians and about 33 percent among Alaska natives.

- The Indian infant death rate has been reduced by 12 percent.

- The Indian death rate from diseases of the stomach and intestines came down by 26 percent.

This is the first report of a series to be issued regularly so that full, current information on the progress of health services to Indians and Alaska natives may be constantly available.

In calling attention to progress since 1954, neither Dr. Burney nor I wish to give the impression that this country's Indian health problems are solved. This is far from true,

even with respect to tuberculosis. That disease still claims nearly four times more lives among American Indians than among the Nation's general population, and upwards of eight times more Indians contract tuberculosis. The tuberculosis death rate among Alaska natives is more than 10 times greater than the national average.

Health problems among American Indians and Alaska natives still are unique and severe. Language differences combined with limited understanding by Indians of health and disease concepts still constitute obstacles of considerable magnitude. Geographic and cultural isolation on some 250 Federal Indian reservations and in hundreds of native villages in Alaska, combined with an extremely low economic level, are serious handicaps in the provision of services.

The health program operates over tremendous areas in 25 States, including Alaska. Its hospital at Point Barrow, above the Arctic Circle, is the most northerly in the world. In this area, the Public Health Service has medical personnel who drive their own dogsleds and fly their own airplanes. The first operation ever performed in Alaska involving the transplanting of a cornea was on a 16-year-old Eskimo girl in the Public Health Service hospital at Anchorage in December 1958.

Distances, population dispersion, and absence of local water supplies pose severe obstacles for doctors, nurses, health educators, and sanitation personnel in the southwest. One Public Health Service dental officer travels 10,000 miles a year treating his patients on the vast Navajo reservation, which covers an area the size of West Virginia. Construction of an urgently needed new hospital for the Papagos

on the Arizona desert was delayed for months because of difficulties in locating a water supply.

Gross and widespread environmental sanitation problems—notably lack of safe water supply and overcrowded and inadequate housing—persist as the allies of excessive disease rates. These are problems which the Indians are generally unable to correct within their own economic resources. The task ahead is still enormous.

Substantial increases in funds for Indian health during recent years have enabled the Public Health Service to make inroads against critical disease problems. Trained professional staff members, so vital to the success of a direct service operation such as the Indian health program, have been substantially increased in number. A good start has been made in eliminating the generally unsatisfactory condition of Indian health facilities and the shortage of modern medical equipment.

Notable progress also has been made against trachoma, the infectious eye disease which still exists in this country among Indians. Dr. Phillips Thygeson, internationally recognized

authority on this disease, serves as the Public Health Service's consultant in planning and developing trachoma control activities. His "Trachoma Manual and Atlas" published last year by the Service is, I am told, a valuable aid in the diagnosis and treatment of trachoma not only among Indians but in other countries where this disease is a major health problem.

Although Indian infant deaths dropped 12 percent in the 4 years ended with 1957, the Public Health Service recognizes that the present rate of 57 deaths per 1,000 live births is excessively high. Increasing numbers of Indian babies are born in the Service's Indian hospitals, and as a result the Indian infant death rate in the first month of life now compares favorably with that of the general population. However, because of unfavorable environment, Indian infants die at more than five times the rate for the population as a whole during the succeeding 11 months of life.

We will never be satisfied until the health of the Indians is fully comparable with that of most Americans. It is our aim not only to hold present gains but to increase our efforts in this field.

New Reports on Death Rates

A new series of 62 reports presenting age-specific and age-adjusted death rates is being released by the National Office of Vital Statistics, Public Health Service. The series, *Vital Statistics—Special Reports Volume 49*, is entitled "Death Rates for Selected Causes by Age, Color, and Sex: United States and Each State."

These reports include both age-adjusted and age-specific rates for the average of the 3 years 1949, 1950, and 1951.

With the exception of No. 1, which summarizes data on death from all causes, each number contains data for a single cause of death or group of related causes. The reports follow the classifications in the "Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death." Thirty of the series have already been released, and the remainder are scheduled for publication during 1959.

Copies are available from National Office of Vital Statistics, Public Health Service, Washington 25, D.C.

Each nation in the Western Hemisphere has a concern with childhood accidents, which vary in nature according to geography, technology, and custom.

Accident Prevention in Childhood

JAMES L. GODDARD, M.D., M.P.H.

ACCIDENTS are the leading cause of death in children 5 to 14 years of age in 13 countries of the Western Hemisphere. If trends of the past two decades continue, we shall find within 20 years that in many nations of the Americas accidents will constitute the leading cause of death for all age groups 1 to 15 years.

Granted the urgency of organizing a broad attack on the childhood accident problem, how shall we proceed?

Once the established techniques of factfinding and casefinding have defined the task of preventing childhood accidents in any given area or community, the procedure eventually emerges.

Each specific accident hazard requires specific methods of prevention. The traffic-filled street in New York or Rio de Janeiro, the Texas ranch, or the Peruvian mountain village contains unique hazards in a unique setting, requiring its own preventive program.

Mortality and Morbidity

Nothing illustrates more clearly the geographic variation in the relative significance of accidents to children than an analysis of mortality tables for the 17 countries of the Americas and Puerto Rico, Jamaica, and Trinidad. Data on the five principal causes of death, with rates per 100,000 population, for children in

two age groups, 1-4 and 5-14 years, for 1956 are given in figures 1 and 2. In considering death rates in these two age groups, it should be noted that the rates are much lower for the age period 5-14 years than for the age period 1-4 years in many countries where disease still takes a high toll.

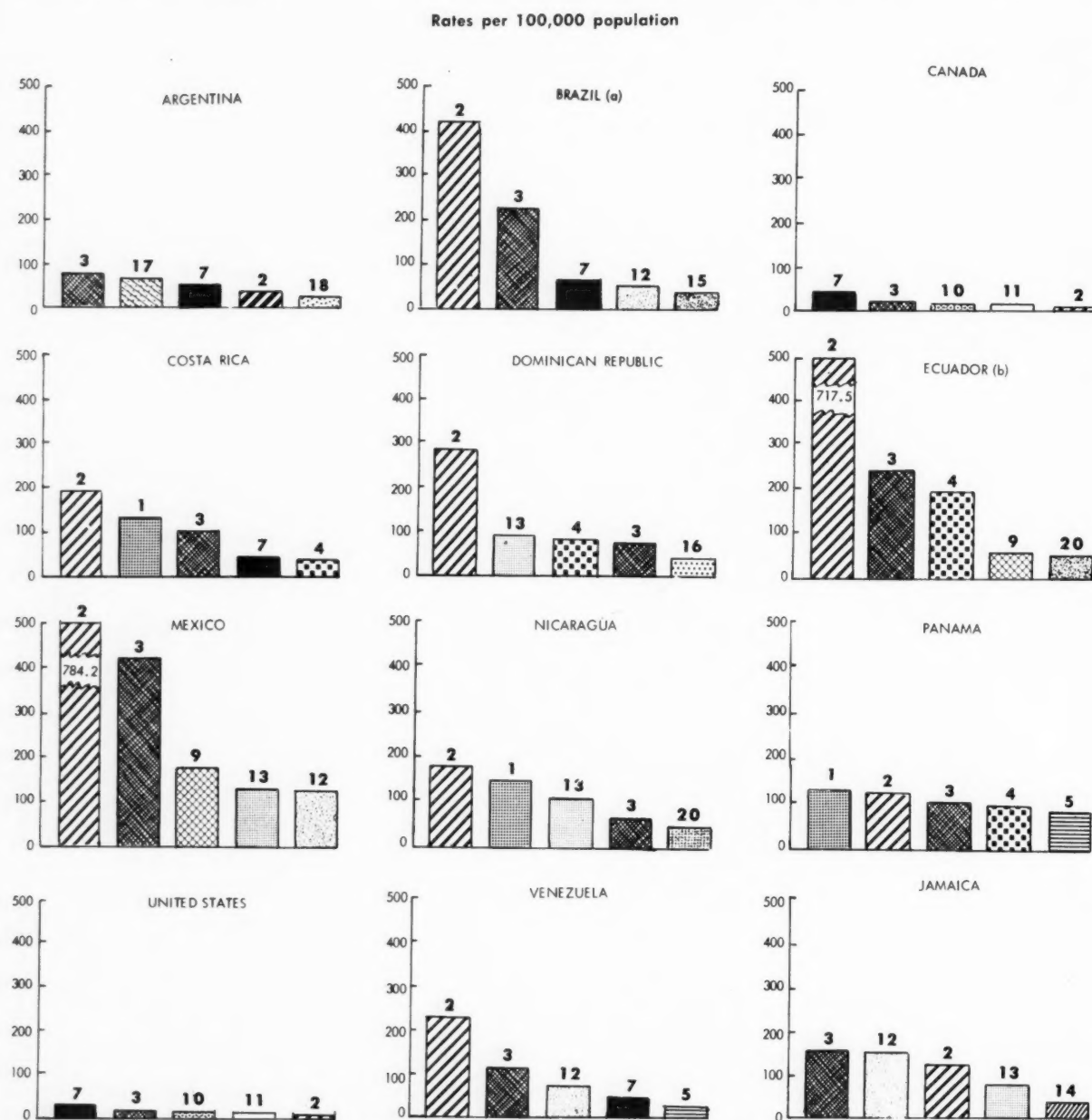
Only in the United States and Canada were accidents the leading cause of death in the 1-4 age group. In only eight of the remaining countries were accidents even listed among the five leading causes of death. In the 5-14 age group, however, accidents are the leading cause of death in two-thirds of the countries reporting, and only in Guatemala are accidents missing from the five chief causes of death. The highest rate given is for Ecuador, where the figure (39.7) is almost double the United States rate of 20.

The California Health Survey of 1954-55 reveals that incidence of illness from accidents ranks second only to diseases of the respiratory system for children under 15 years of age (table 1).

For those who survive the common diseases of infancy and childhood, there is the ever-

Dr. Goddard is chief of the Accident Prevention Branch, Public Health Service. This article is based on a paper presented at the 15th Pan American Sanitary Conference held in San Juan, Puerto Rico, September-October 1958.

Figure 1. Principal causes of death among children 1-4 years of age in the Americas, 1956.



^a Includes only Federal District and seven State capitals.

^b Includes only capital cities of provinces.

SOURCE: Summary of Four-Year Reports on Health Conditions in the Americas, Scientific Publication No. 40, Pan American Sanitary Bureau, June 1958.

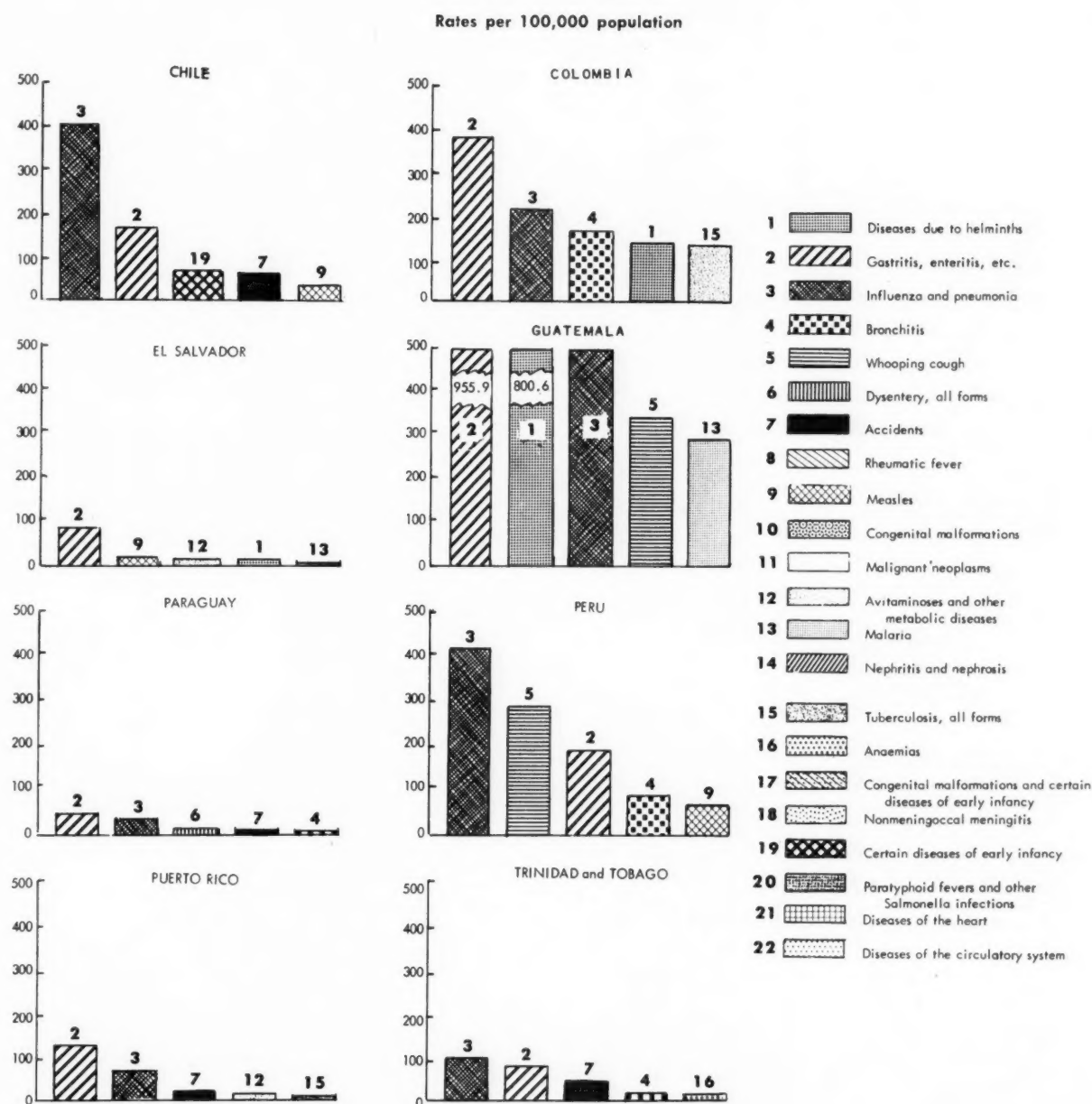
present threat of death or injury from accidents. This threat is both widespread and complex.

On the basis of the first 6 months' report of the National Health Survey in the United States, it is estimated that approximately 16 million children are injured each year, with the rate about twice as great in boys as in girls.

Of girls under 15 years of age, one child in three is injured each year, and most of them are injured in and around the home.

Throughout the Americas, frequently encountered causes of accidental death in children are motor vehicle accidents, drowning, burns, poisoning, falls, and bites from poisonous insects or snakes.

Figure 1. Principal causes of death among children 1-4 years of age in the Americas, 1956—Continued.

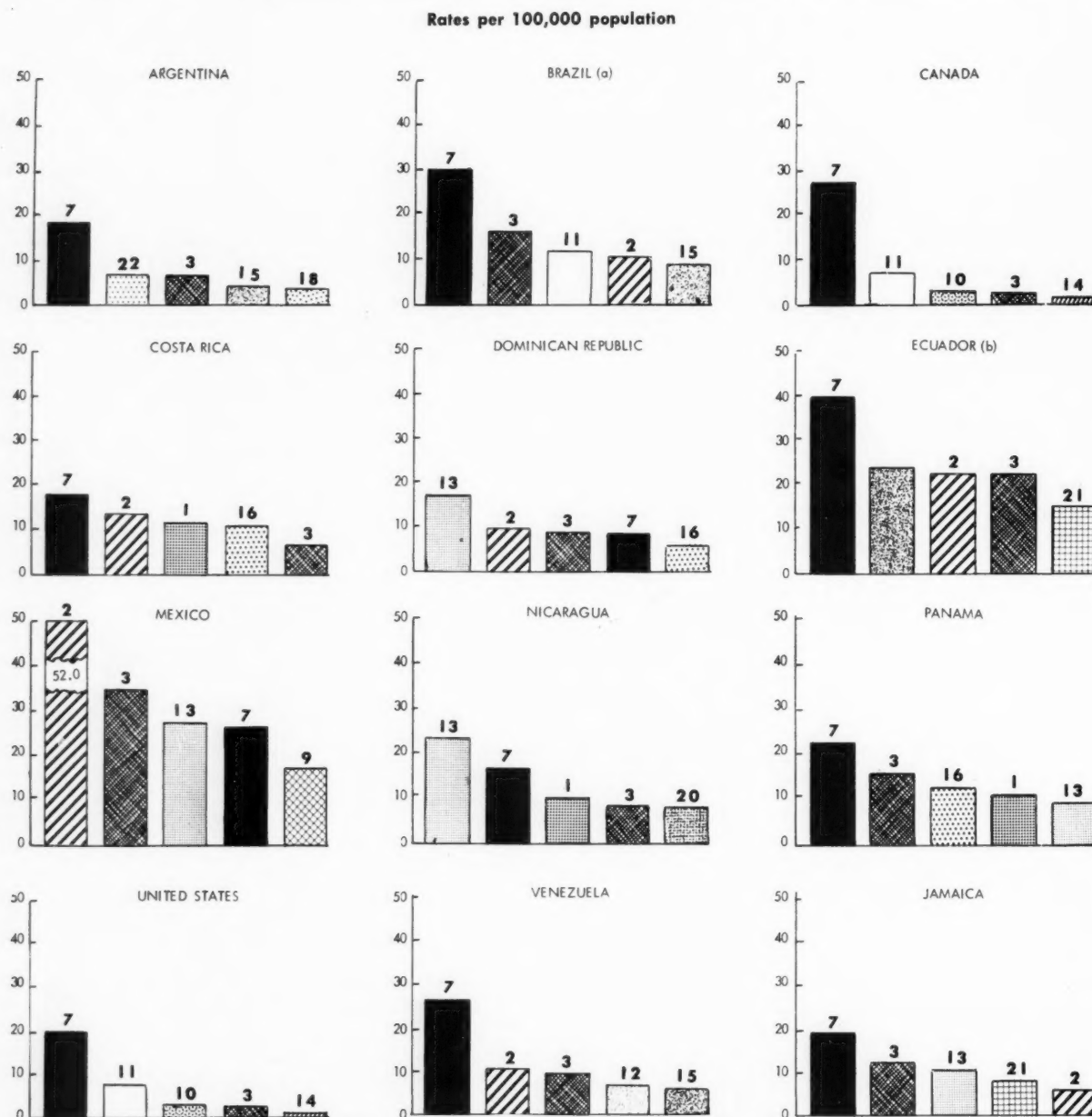


The number of reported deaths of children 1-4 and 5-14 years of age from accidents, with rates per 100,000 population, in the Americas is presented in table 2.

Analysis of specific causes of mortality for the United States and Venezuela reveals a greater number of both fatal and nonfatal injuries among boys. It is generally assumed that the growing boy is more active and more inclined to take risks than a girl of the same

age. There are also other striking differences. In the 5- to 14-year-old girls in Venezuela, for example, burns are the most frequent cause of accidental death. In boys of the same age, drowning is the most frequent cause, and burns rank fifth. Obviously such differences are related to exposure factors. The risk of drowning is greater for boys because more boys are exposed to the risk. Burns are more frequent for girls because they spend more time in the

Figure 2. Principal causes of death among children 5-14 years of age in the Americas, 1956.



^a Includes only Federal District and seven State capitals.

^b Includes only capital cities of provinces.

SOURCE: Summary of Four-Year Reports on Health Conditions in the Americas, Scientific Publication No. 40, Pan American Sanitary Bureau, June 1958.

home at this age, learning how to cook and, of special importance, wearing clothing more susceptible to fire hazards (table 3).

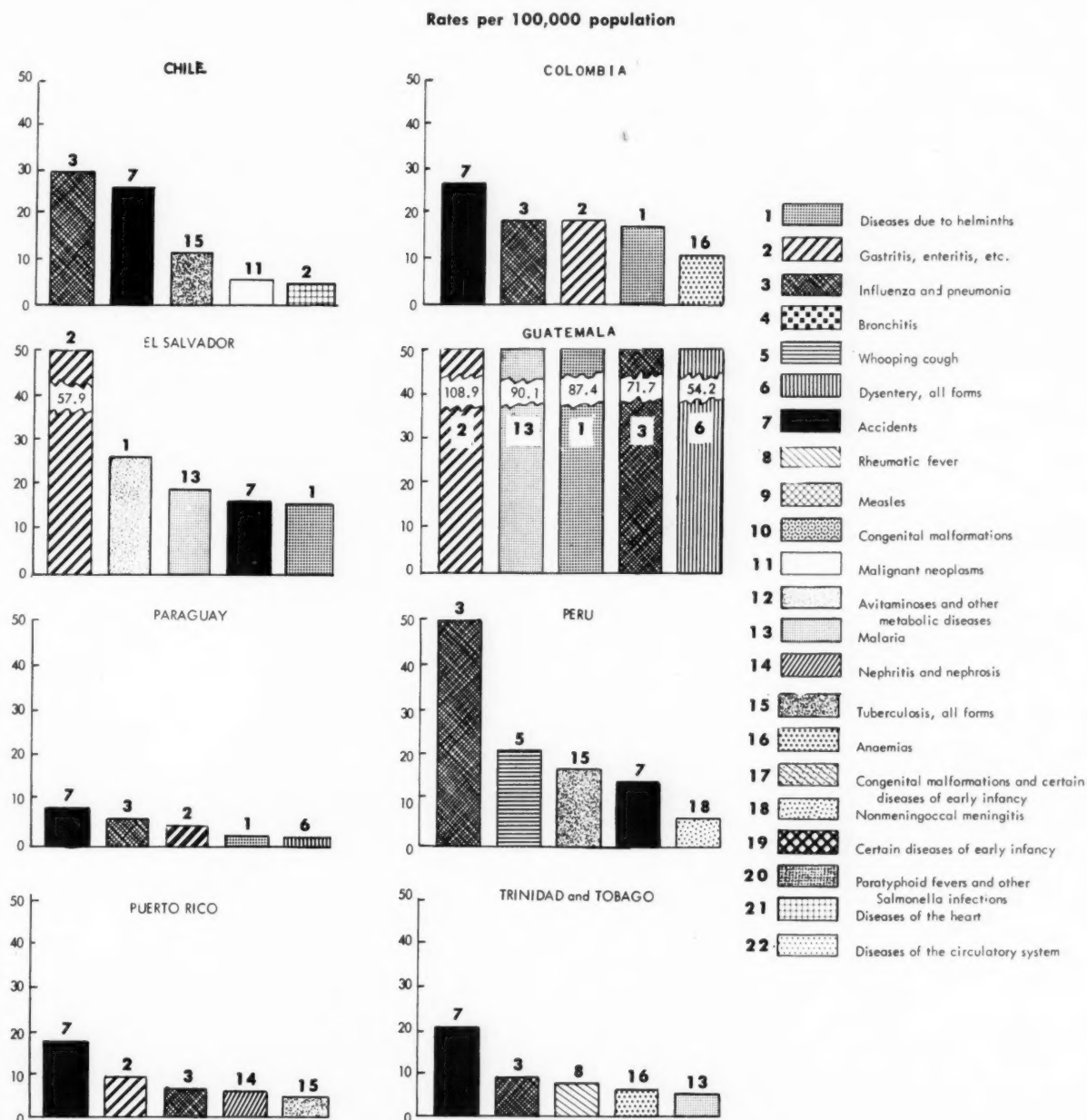
In Puerto Rico, a slightly different pattern is noted for the age group 1-4. Poisoning is the leading cause of accidental death, followed by burns, motor vehicle accidents, drowning, and falls.

In Mexico, deaths from tetanus are frequent in the age group 5-14. Most cases of tetanus are preceded by an untreated injury, usually a laceration or puncture wound of the foot.

Poisonings

Accidental poisoning is a special threat, particularly to children under 2 years of age. The

Figure 2. Principal causes of death among children 5-14 years of age in the Americas, 1956—Continued.



common agents responsible for fatalities in the United States are petroleum products, aspirin and salicylates, arsenical compounds, and lead and its compounds (table 4).

Central and South American countries also report that petroleum products and pesticides are frequently the cause of fatal poisonings.

Better definition of the problem of accidental poisoning is possible when hospitals and emergency centers keep simple but accurate records

of the causative agents. The experience of 23 poison control centers in the United States is summarized by type of substance in table 5.

In approximately 25 percent of those cases involving medicine, aspirin or other salicylates were ingested. Aspirin may not be quite so widely available elsewhere. In 230 poisoned patients seen in 1 year at a children's hospital in South America, only 2 had swallowed aspirin or salicylates. Petroleum products and bleach-

Table 1. Selected measures of illness by diagnosis for children under 15 years of age, California, 1954-55: Rates per 1,000 children per year

Diagnostic group	Incidence of illness	Days of disability	Hospital admissions	Hospital days
Total.....	5, 243	17, 340	41	229
Infectious and parasitic diseases.....	260	2, 680	2	29
Neoplasms.....	10	120	1	4
Cardiovascular diseases.....	20	380	-----	-----
Diseases of respiratory system.....	2, 520	8, 810	16	36
Diseases of digestive system.....	635	1, 590	5	38
Accidents.....	1, 033	700	6	31
All others.....	765	3, 060	10	93

SOURCE: California Health Survey, Health in California, California State Department of Public Health, September 1957.

ing fluid were the two most frequent poisons reported by this institution.

Site of Accidents

Although detailed data on the sites of childhood accidents are not now available, preliminary analysis of the U.S. National Health Sur-

vey data for all age groups shows that 45 percent of all accidental injuries occur in the home, 30 percent in public places, 14 percent at work, and 10 percent on the highway. A study of accident cases treated in the emergency room of the municipal hospital in San Juan, Puerto Rico, had a somewhat similar pattern of results: 56 percent of all injuries were caused by home accidents, 34.5 percent were accidents at public places, 6 percent were motor vehicle accidents, and 3.5 percent were work accidents.

The use of a uniform accidental injury report, such as form PHS-2916, obtainable from the Accident Prevention Branch, Public Health Service, Washington 25, D.C., can provide a wealth of data in a short time. On the basis of data gathered, preventive measures can be designed to meet the specific preventive needs.

Causative Factors

Accident causation is beginning to inspire formal research programs of an increasingly elaborate nature. Almost every one of the physical, natural, and social sciences has something to contribute to our understanding of this problem.

There is some risk at this stage, therefore, of being overwhelmed by the complexity of re-

Table 2. Number of deaths from accidents in children 1-4 years and 5-14 years in the Americas, with rates per 100,000 population, 1956

Area	1-4 years		5-14 years		Area	1-4 years		5-14 years	
	Number	Rate	Number	Rate		Number	Rate	Number	Rate
Argentina ¹	690	42. 9	² 670	18. 6	Mexico ³	2, 056	56. 5	2, 091	26. 7
Brazil ⁴	324	61. 8	309	30. 1	Nicaragua.....	40	25. 6	59	16. 8
Canada ⁵	702	45. 5	895	27. 7	Panama.....	30	26. 5	52	23. 1
Chile.....	423	61. 9	416	26. 2	Paraguay.....	29	14. 1	37	8. 4
Colombia.....	897	53. 2	904	27. 0	Peru ¹	289	30. 3	310	14. 6
Costa Rica.....	47	37. 2	47	18. 1	United States ³	4, 791	32. 6	6, 099	20. 0
Dominican Republic ³	76	21. 7	56	8. 3	Venezuela.....	329	43. 2	369	25. 6
Ecuador ^{3 6 7}	56	49. 7	89	39. 7	Jamaica ⁸	46	29. 9	67	18. 4
El Salvador ³	61	23. 5	93	16. 6	Puerto Rico ³	61	20. 2	102	16. 9
Guatemala ³	61	14. 2	145	17. 5	Trinidad and Tobago.....	38	44. 3	34	20. 9

¹ Year 1953.

² Detailed list numbers E800-E999.

³ Year 1955.

⁴ Federal District and 7 State capitals.

⁵ Excluding Yukon and Northwest Territories.

⁶ Capital cities of provinces.

⁷ Rates based on population estimated by the Pan American Sanitary Bureau.

⁸ Year 1954.

SOURCE: Summary of Four-Year Reports on Health Conditions in the Americas, Scientific Publication No. 40, Pan American Sanitary Bureau, June 1958.

search needs or confused by the tremendous scope of research possibilities. Every aspect of the classic epidemiological trinity (host, agent, environment) undoubtedly contains secrets that will ultimately yield to study and enhance our understanding of accident causation.

To help define the child as an "accident host," clearly we need to learn as much as we can about his growth and development, about the relationship between his mental and physical condition and accidents, about his educational background and progress.

The "agent" in childhood accidents can be almost anything he contacts, and this group of causative factors must be studied in a systematic and specific way if even limited progress is to be made. The motor vehicle is a prime example of an accident agent that is readily identified and isolated for study. Specific toxic substances that cause accidental poisoning offer a similarly delimited field of study.

In general, advances will be achieved by careful pursuit of specific study goals.

The child's "environment," the third element in the epidemiological triad, is as small as the crib or as large as the whole community, depending upon the age of the child. Geography, climate, economics, sociology, even history and politics play a part in molding the child's environment and in creating the causative relationship between that environment and accidents.

Since space does not permit an exhaustive analysis of this multitude of causative factors, we must be content with calling attention to a few dynamic factors. Common to all accidents are the person and the environment; their respective susceptibility and potential; habits, attitudes, and patterns of operation; specific changes, events, or irregularities in the pattern; and the built-in protective factors or feedbacks which may affect or avert the trigger action.

"Accident susceptibility" is obviously strong in a child because this factor is conditioned by training, experience, and judgment. Also, such special physiological and mental factors as illness, emotional upsets, and the like may be expected to affect children even more drastically than adults.

Finally, the "unsafe act or trigger mechanism" is clearly illustrated when a child starts a fire while playing with matches, or swallows poison while in search of candy.

In short, close study of such dynamic factors will well repay all who are professionally or personally concerned with improved accident prevention techniques based on better understanding of the causative factors. These have been charted graphically (1).

Prevention

Effective programs for the prevention, control, and amelioration of the effects of childhood accidents will be achieved through definition of the problem, formulation of specific hy-

Table 3. Accidental deaths in children according to the five principal types in the continental United States, 1956, and in Venezuela, 1954, by sex and age group

Type of accident	Continental United States		Venezuela	
	Males	Females	Males	Females
1-4 years				
Motor vehicle.....	800	638	28	22
Drowning.....	463	191	47	38
Fire and explosion of combustible material.....	443	472		
Poisonings, solid or liquid.....	196	140	28	19
Falls.....	155	99		7
Burns.....			26	27
Poisonous bites by venomous animals.....			6	
5-14 years				
Motor vehicle.....	1,785	855	44	28
Drowning.....	981	204	55	15
Firearms.....	357	72		
Fire and explosion of combustible material.....	263	404		
Falls.....	138	50	19	4
Poisonous bites by venomous animals.....			39	6
Burns.....			15	31

SOURCES: For continental United States, U.S. National Office of Vital Statistics, Vital Statistics of the United States, 1956; for Venezuela, unpublished data from División de Epidemiología y Estadística Vital, Dirección de Salud Pública, Ministerio de Sanidad y Asistencia Social, República de Venezuela.

potheses, testing and validation of the hypotheses, and translation of findings into action.

Since each accident results from a multiplicity of causative factors, no single solution can be expected. Diversities in cultural patterns, environmental conditions, and host factors necessitate careful selection of preventive activities.

Recommended activities are presented here with respect to principles of primary and secondary prevention. Many principles are, of course, applicable to both.

Primary Prevention

DEFINITION: There is a serious lack of sufficient data concerning accidents in childhood. Mortality and morbidity data, supplemented by special epidemiological studies, are the conventional sources of such information. In those Latin American countries where hospital and emergency services are provided by the government, data on accidental injuries may be obtained more readily than in voluntary or private institutions in Canada and the United States.

The minimum requirements of an accident reporting system include the following items for each injured patient: age, address, sex, race, marital status, occupation, hour, day, and date

Table 5. Accidental poisoning cases by type of substance ingested, reported by poison control centers in 23 areas of the United States¹

Type of substance	Treated cases		Telephone inquiries	
	Number	Percent	Number	Percent
Medicines.....	3,354	52.3	449	28.2
Internal.....	3,063	47.8	354	22.2
External.....	291	4.5	95	6.0
Household preparations.....	687	10.7	430	27.0
Petroleum distillates.....	484	7.6	29	1.8
Cosmetics.....	69	1.1	163	10.2
Pesticides.....	800	12.5	214	13.4
Gases and vapors.....	5	.1	10	.6
Plants.....	59	.9	61	3.8
Paints, solvents, etc.....	159	2.5	83	5.2
Other.....	739	11.5	151	9.5
Not stated.....	51	.8	4	.3
Total.....	6,407	100.0	1,594	100.0

¹ Various time periods from July 1954 through November 1957.

SOURCE: Tabulated reports submitted to the National Clearinghouse for Poison Control Centers from local poison control centers.

of the accident, activity of the injured person at the time of the accident, nature of the injury, part of the body injured, severity or condition of the patient, name and address of the

Table 4. Number of deaths due to accidental poisoning by type of solid and liquid substances among children under 15 years of age, continental United States, 1952-56

Type of substance	1952	1953	1954	1955	1956
Morphine and other opium derivatives.....	5	5	3	5	2
Barbituric acid and derivatives.....	9	11	14	8	16
Aspirin and salicylates.....	86	71	86	75	71
Bromides.....	1	1	1	1	1
Other analgesic and soporific drugs.....	6	13	3	8	10
Sulphonamides.....	1	1	1	1	1
Strychnine.....	14	15	9	9	4
Belladonna, hyoscine, and atropine.....	4	4	2	2	1
Other and unspecified drugs.....	47	44	49	36	34
Noxious foodstuffs.....	1	1	3	2	1
Alcohol.....	6	10	6	4	4
Petroleum products.....	111	102	83	71	88
Industrial solvents.....	10	11	9	11	8
Corrosive aromatics, acids, and caustic alkalies.....	30	30	21	16	16
Mercury and its compounds.....	4	1	1	1	1
Lead and its compounds.....	45	52	34	49	34
Arsenic and antimony, and their compounds.....	23	27	22	24	40
Fluorides.....	1	1	1	1	1
Other and unspecified solid and liquid substances.....	60	71	72	68	96
Total.....	462	468	418	389	426

SOURCE: Unpublished data from the U.S. National Office of Vital Statistics.

hospital and attending physician, and identification of the reporter.

Such data may be supplemented by analysis of death certificates. As programs are developed, routine specification on the death certificate of the type of fatal accident will be required.

The study of accidents by type (motor vehicle, falls, drowning, poisoning) and by type of injury (burns, lacerations, wounds) helps to suggest remedial measures. Defects in design of equipment or environmental hazards are frequently exposed by such analysis.

The redesign of refrigerators has been undertaken as a consequence of studies which revealed how many children crawled into discarded ice-boxes and were locked in.

The Cornell University Automotive Crash Injury Research project has profoundly influenced the design of passenger cars in the United States. The importance of the safety belt, validated by the Cornell studies, has altered the thinking of automotive safety engineers.

In a rural area of Georgia, an epidemiological study, inspired by the high incidence of burns reported among children there, formed the basis for a public health program to encourage the use of screens in front of fireplaces.

A Latin American analogy may be found in rural Chile where a brazier on the floor or the ground is the usual equipment for cooking. Protective devices, coupled with public health educational campaigns, could diminish this particular threat.

Knowledge of the relationship between childhood growth and development and accident patterns at different ages is necessary for educational programs directed to parents and schools. Longitudinal studies, while expensive and time consuming, will always be necessary.

The discriminate use of surveys on cross sections of population groups also helps in identifying and defining needs.

Retrospective study of deaths from accidents using supplemental death certificate forms has been made for years in different parts of the United States. The data have been useful in educating the public and in alerting health workers to hazards.

EDUCATION: Education is an elementary step

in accident prevention. In all fields, education progresses as distribution of information is fortified by experience.

Public health agencies need to be equipped with appropriate information and skills and motivated to accept educational responsibility when they attempt accident prevention.

The staff of a health agency may help other groups in the community and the citizens of the community themselves to acquire the necessary facts, equipment, and habits.

Physicians are one of the essential groups in accident prevention. They become excellent teachers. No medical practitioner speaks with more authority on safety for children than the pediatrician. Dr. Harry F. Dietrich defines the pediatrician's role as follows: (a) he must gain an enlightened awareness of the problem; (b) he must attempt to immunize his patients against serious accidents by providing parents with the theory of accident prevention and sufficient advice and encouragement to apply it; (c) he must alert the entire medical profession to the gravity and needs of the problem; and (d) he must enlist the aid of all available organizations in a continuous community and national campaign to prevent childhood accidents.

To this, perhaps, should be added: (e) he can alert us to new hazards; and (f) he can, by virtue of his detailed knowledge of the patterns of growth and development (both mental and physical), advise us as to the appropriateness and acceptability of preventive measures.

The school teacher is also important in accident prevention, as are all key leaders in the community.

It is the opportunity of the health agency to organize, stimulate, coordinate, inspire, and, sometimes, to finance cooperative efforts by all components of the society.

COORDINATION OF ACTIVITIES: The prevention of childhood accidents is of concern to many governmental agencies, traffic departments, and departments of education, health, social security, and labor. There is clearly a need for closer coordination between agencies engaged in this common effort. The role of the health agency in some instances actually may be limited to coordination; in other situations, the health department may play a direct role as well.

Coordination of health agency activities with educational departments is particularly important. The teaching of safe living has long been accepted as a responsibility of the schools in the Americas. In this work, health agencies assume a subordinate role, which initially may be limited to provision of suitable and up-to-date material. Later it may be possible to propose and assist in the development of preventive activities, such as swimming classes for preschool children as well as school children.

The frequency of traffic accidents suggests the need for coordination among several agencies. In countries such as the United States, Canada, and Mexico, where school-boy patrol activities have been initiated, liaison has been effected between the education and traffic departments. Extension and improvement of such programs is a goal of many health agencies.

Another civic activity is the development of adequate recreational facilities for children. A well-planned recreational program helps in keeping youngsters off the streets and away from traffic hazards. Again, such a program is seldom the direct responsibility of the health agency, but the demonstration of the need and recommendations for action could be.

LEGISLATION: In many instances, special hazards to children have been eliminated or controlled by the enactment and enforcement of legislation.

For example, in the United States flammable fabrics in children's clothing were brought under Federal regulation by act of Congress. The U.S. Congress has similarly acted to protect the public by legislation on the manufacture and sale of insecticides.

There are similar problems throughout the Americas, and as the reporting of injuries is improved, new hazards will be exposed which may warrant legislative control.

RESEARCH: There is obviously a need for developing and continuing operational research, as exemplified by surveys, analyses of hospital data, and analyses of death certificates. In addition, it is essential to initiate and expand basic research on human factors in accidents.

As has been mentioned, the epidemiological technique lends itself readily to studies in the accident field. McFarland, Gordon, and others

have pointed out the value of applying the principles of epidemiology to the study of accidents. Use of this technique already has led to reductions on a limited scale in certain types of injuries and deaths. In the past, these have been related usually to environmental factors or agent factors immediately associated with accidents.

One value of the epidemiological approach is that it facilitates appraisal of the data collection process. Epidemiological studies provide the basis for determining the value of data currently being collected, as well as pointing out the need for routine collection of additional data.

A second type of important research is related to improving education. Practically nothing has been done as yet to increase understanding of why people accept or reject recommendations for their own safety, or how various cultures are influenced in acceptance or rejection of specific practices.

A third type of essential research relates to improvement in treatment of injuries, through planned cooperative study involving several hospitals or treatment centers. One example is the study of kerosene poisoning now being conducted in the United States by the American Academy of Pediatrics, the American Public Health Association, and the Public Health Service. By pooling data from numerous hospitals, it is hoped that the question of the value of lavage in these cases can be reliably determined. Another such study could be carried out to compare the results from various treatments for serious burns.

The clinical study or case study will also be valuable in childhood accident prevention. The individual clinician, and particularly the pediatrician, can make a significant contribution through careful observation and analysis of patients seen day-to-day.

Secondary Prevention

Hazards to children are not wholly eradicable. Thus efforts must be directed not only toward a reduction of fatal accidents but also toward amelioration of the effects. Prevention of deaths from secondary causes and prevention or modification of disabilities are, there-

fore, aspects of the accident problem that cannot be neglected.

IMPROVEMENT OF EMERGENCY SERVICES: It was conclusively demonstrated during World War II that survival rates, length of hospitalization, and even the degree of disability could be related to the quality and distribution of emergency care.

The significance of careful handling of the victim, from the time of injury until definitive care begins, is appreciated by the medical profession. Unfortunately, their concern has not always been communicated to those responsible for emergency services.

There are three major elements involved in the care and transport of the injured: training of personnel, adequacy of equipment, and distribution of services in relation to population and the facilities used by the population.

Untrained ambulance attendants, inadequate equipment, speeding ambulances, lack of services in rural areas (as well as in some urban areas) are common throughout the Americas. Curry and Lyttle (2), in their excellent description of how one community was successful in overcoming these difficulties, provide a blueprint that can be adopted by others.

Adequate emergency room services are vital to secondary prevention. The controlling factors are again the training of personnel, the adequacy of equipment, and the availability of services. The special problem presented by accidental poisoning demonstrates the importance of recognizing these factors. Not only must the physician be capable of directing or providing general treatment for the child, he must, because of the multitude of possible toxic agents, be able to track down the specific ingredient.

The prevention of secondary complications is not limited to proper treatment for poisoning. Lack of treatment or inadequate treatment may introduce further stresses. For example, in Mexico, as has been pointed out, there are a significant number of deaths each year caused by tetanus in the age group 5-14 years.

REHABILITATION SERVICES: Applied early, rehabilitation services contribute to reduction in the degree of disability following severe injury. Indeed, the caseload of rehabilitation centers in the Americas is comprised largely of accident

victims. As more of these facilities are developed and the time lag between injury and rehabilitation services is decreased, a marked improvement can be expected. Although the expense of rehabilitation is usually well justified, the prevention of serious injury is even more economical.

Summary

Extension of current trends suggests that accidents will, within the next two decades, be the leading cause of death in children 1 to 15 years of age in many nations of the Americas.

Rehabilitation centers in the Americas report that caseloads are comprised largely of accident victims.

Each specific hazard must be identified and prevented on an individual basis, but traditional public health procedures, such as epidemiology, provide tested methods.

Although diseases such as gastritis and enteritis are the first cause of death for half the countries of the Americas in the 1 to 4 age group, accidents are the leading cause in two-thirds of these countries in the 5 to 14 age group. Nonfatal accidents are found to cause great economic loss because of resultant disabilities and longer and more expensive hospitalizations. Motor vehicle accidents, drowning, burns, poisoning, falls, and bites of insects and snakes are leading causes of accidental death. With significant exceptions, boys have more accidents than girls. More than one-half the accidental poisoning cases occur under 2 years of age, the toxins varying from country to country.

Mortality and morbidity data gathered from surveys are essential bases for initiating accident prevention activities by health departments. U.S. National Health Survey data indicate 45 percent of all accidental injuries occur in the home.

Accident survey data help to define epidemiological study areas and aid evaluation of programs. Accident causation, the subject of increasing study, is extremely complicated and awaits the application of a multidiscipline approach. The host-agent-environment triad of the epidemiological method is relevant. Accurate record systems are essential to accident studies. Analysis of accurate records has made

possible specific successful prevention activities in the United States and can serve other nations of the Americas.

Both longitudinal and retrospective studies of childhood accidental deaths and injuries contribute to prevention.

Primary and secondary prevention benefit equally by educational activities. Education in accident prevention is also a major duty of a public health agency. Physicians can perform valuable educational work in this field.

Health departments can establish leadership in accident prevention and coordinate the work of other community groups.

Research is needed in epidemiology, educational techniques, and emergency treatment and first aid. Emergency treatment services can be greatly strengthened as a secondary prevention technique.

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Epidemiological Notes

Meningococcal Infections

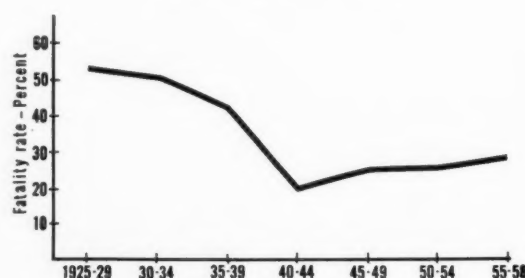
A progressive decline in mortality from certain bacterial infections followed the introduction of sulfonamides in 1937 and of antibiotics in the next decade. The fatality rates for meningococcal infections declined from a level of about 40 percent just prior to the use of sulfonamides to about 20 percent during the next few years. However, in the past 15 years the fatality rate has remained at a slightly higher but relatively constant level of about 25 percent, as shown in the chart.

The two principal classes of meningococcal infections are meningitis and septicemia. The number of deaths for each of these types has fluctuated with increases and decreases in reported incidence of cases. About 1950 approximately two-thirds of all deaths from meningococcal infections were attributed to meningitis, but during the past few years there has been about the same number ascribed to meningococcemia as to meningococcal menin-

gitis. Since no morbidity data by type of infection are available, it cannot be determined whether the septicemic form is becoming relatively more frequent.

The number of deaths from meningococcal infection currently reported annually is about 800, which is far in excess of those from diphtheria, measles, streptococcal sore throat and scarlet fever, typhoid fever, or whooping cough. Since 1955 meningococcal infection has outranked poliomyelitis as a cause of death.

Case fatality rates for meningococcal infections, United States, 1925-58.



The fact that this acute infection causes 800 deaths a year and 1 fatality for every 4 cases reported suggests the need for the development of more effective methods for its control.—DR. CARL C. DAUER, *medical adviser, National Office of Vital Statistics, Public Health Service.*

Poliomyelitis in the United States, 1957

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POLIOMYELITIS reported in the United States during 1957 reached the lowest level since 1942. A total of 5,485 cases were reported to the National Office of Vital Statistics, Public Health Service, a rate of 3.2 per 100,000 population. Of these cases, 2,499 were reported as paralytic, and 2,826 nonparalytic. The paralytic status was unspecified for the remaining 160 cases.

Table 1 presents total national poliomyelitis incidence rates from 1935 through 1957 as reported to NOVS. Although wide annual variations occurred, the incidence of poliomyelitis remained high from 1948 through 1955. During 1956, half as many cases occurred as during the previous year, while in 1957, reported cases were only one-fifth of the 1955 figures.

Seasonal Distribution

Variability in seasonal distribution patterns as well as in annual poliomyelitis incidence in recent years is further apparent from figure 1, which presents the seasonal curve of weekly reports to NOVS for the years 1942, 1947, and 1952 through 1957.

For paralytic poliomyelitis alone, as shown in figure 2, the seasonal rise in 1957 was gradual, and peak incidence was not reached until

the end of September (39th week), much later than the late August peaks reached in 1955 and 1956. Data specifying paralytic status, prior to 1955, are not available on a nationwide scale.

During 1957 the seasonal distribution curve for paralytic poliomyelitis differed considerably from nonparalytic poliomyelitis. Cases reported in the poliomyelitis surveillance program during 1957 by week of onset are presented in figure 3. Whereas nonparalytic disease reached a sharp, seasonal peak in early August, paralytic poliomyelitis rose gradually to a minor peak in early August and subsequently remained at a plateau, not reaching maximum weekly incidence until almost 2 months later. The proportion of paralytic cases among reported poliomyelitis cases was notably lower in all regions of the country during July and August as compared with the remainder of the year.

Morbidity Reporting

In recent years increasingly widespread application of virus diagnostic tissue-culture techniques has permitted study of numerous outbreaks of nonparalytic aseptic meningitis. It is now well documented that many agents of the ECHO and Coxsackie groups are capable of producing an illness clinically indistinguishable from aseptic meningitis caused by the poliovirus. On rare occasions these agents have also been associated with paralytic disease.

During 1957, large outbreaks of illness with aseptic meningitis syndrome due to nonpoliomyelitis enteroviruses were recorded in many States, including Wisconsin, Minnesota, Michi-

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Data Collection

Basic functions of the National Poliomyelitis Surveillance Program are the continual collection of data on the safety and efficacy of poliomyelitis vaccine and the study of the epidemiological trends of poliomyelitis in the United States. Established in April 1955 at the Communicable Disease Center of the Public Health Service, the program is based on participation by local and State health departments, the National Office of Vital Statistics, diagnostic and research laboratories, the National Foundation for Infantile Paralysis, and others with responsibility and interest in the field of poliomyelitis and poliomyelitis-like diseases. Mimeographed Poliomyelitis Surveillance Reports are issued regularly, reviewing data reported in the program. In addition to these periodic reports, reviews of information recorded in 1955 and 1956 have been presented (1-4).

During 1957, 47 States, the District of Columbia, and three Territories participated with the Poliomyelitis Surveillance Unit in studying data, including age, race, sex, date of onset of symptoms, paralytic status, and vaccination status of reported poliomyelitis cases. The present report reviews poliomyelitis incidence during 1957 and summarizes the epidemiological patterns in that year in comparison with 1955 and 1956.

gan, Ohio, North Carolina, Virginia, and Tennessee. These included communitywide epidemics of febrile illnesses often with aseptic meningitis symptoms or skin rash, or both, associated with ECHO-9 virus.

With reported poliomyelitis at a low level, individual case diagnosis has become more important. During the year, a relatively low percentage of cases were paralytic. This percentage was lowest in July and August, the period during which the aseptic meningitis epidemics were occurring. A proportion of the cases reported as nonparalytic poliomyelitis during this time are felt to have been caused by the ECHO and Cocksackie viruses. Included in this group are endemic aseptic menin-

gitis cases, as well as early cases from aseptic meningitis outbreaks later demonstrated epidemiologically and virologically to be due to other than polioviruses.

Routine practices in the morbidity reporting of such cases vary. While a number of non-poliomyelitis aseptic meningitis cases were included in routine morbidity reports as nonparalytic poliomyelitis, data recorded in the epidemiological reports to the Poliomyelitis Surveillance Unit were refined in some States by subtraction of cases from known aseptic meningitis outbreaks initially reported as nonparalytic poliomyelitis.

Distribution

Geographic

In contrast with recent years, no large outbreaks of paralytic poliomyelitis occurred during 1957 in the United States. Table 2 presents poliomyelitis cases reported in the poliomyelitis surveillance program by State and region during 1956 and 1957 and estimated attack rates by paralytic status. The generally low incidence of paralytic disease in all regions is apparent. Highest attack rates for 1957 were reported in the southeastern, south central, and southwestern regions, where paralytic rates were 1.8, 2.9, and 2.0 per 100,000,

Table 1. Total national poliomyelitis incidence, 1935-57

Year	Cases	Rate per 100,000	Year	Cases	Rate per 100,000
1935---	10,839	8.5	1947---	10,734	7.5
1936---	4,523	3.5	1948---	27,902	19.1
1937---	9,511	7.4	1949---	42,173	28.4
1938---	1,705	1.3	1950---	33,300	22.0
1939---	7,339	5.6	1951---	23,386	18.6
1940---	9,826	7.5	1952---	57,879	36.9
1941---	9,086	6.8	1953---	35,592	22.5
1942---	4,033	3.0	1954---	38,476	23.9
1943---	11,540	9.3	1955---	28,985	17.6
1944---	16,935	14.7	1956---	15,140	9.0
1945---	12,101	10.3	1957---	5,485	3.2
1946---	25,196	18.4			

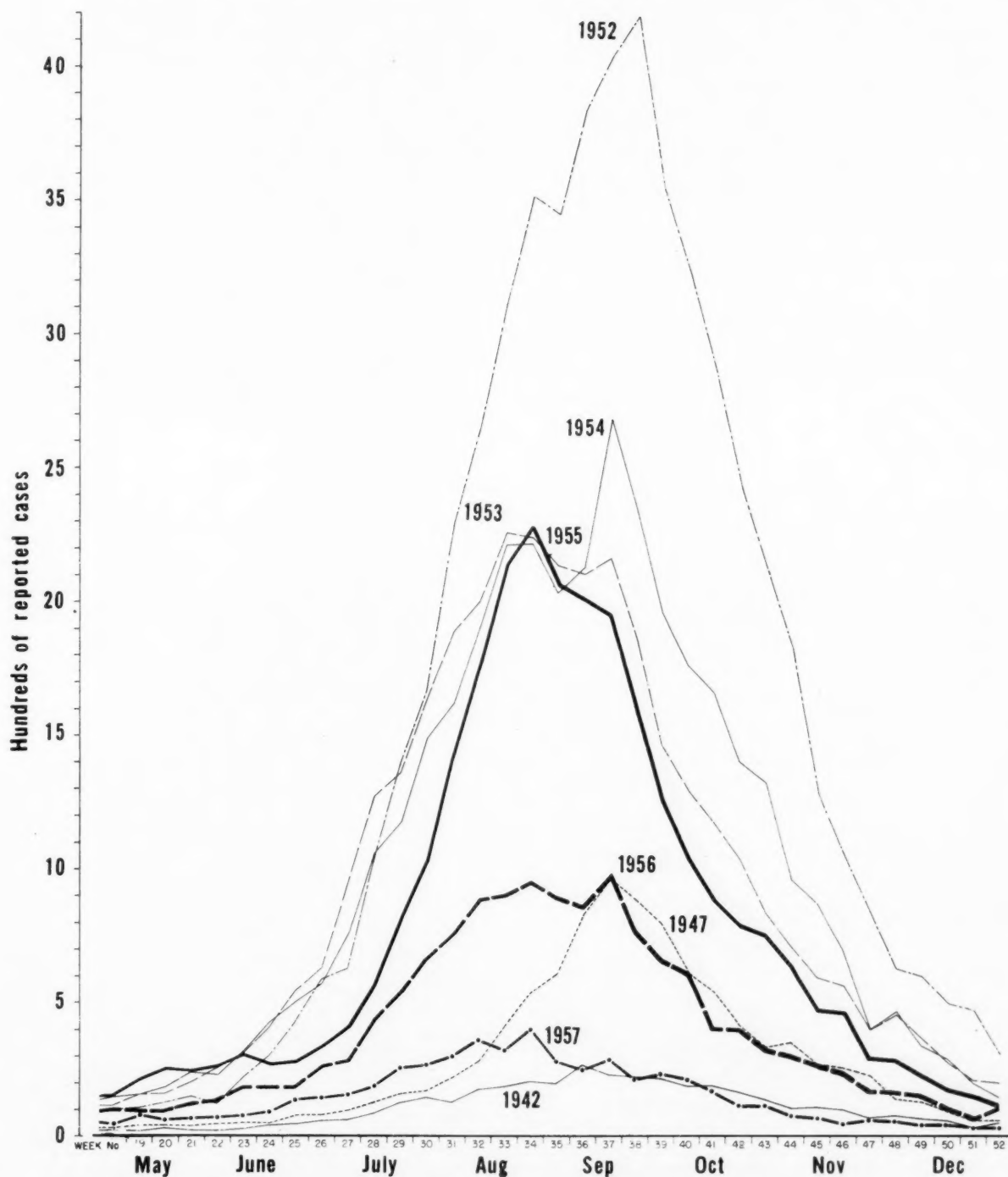
SOURCES: For 1935-1949, The Notifiable Diseases, Annual Reports, Public Health Service, 1935-49; for 1950-57, National Office of Vital Statistics, Weekly Morbidity and Mortality Report, vol. 6, No. 53, Oct. 29, 1958. Population estimates are from the Bureau of the Census.

respectively. Only Texas and the District of Columbia reported more than 3 paralytic cases per 100,000, whereas in 1956 this rate was exceeded in 27 States.

Age

During the past 5 years there has been a progressive rise in the proportion of paralytic cases among preschool children. As shown in

Figure 1. Poliomyelitis incidence in the United States, 1942, 1947, 1952-57.¹



¹ Provisional data from the National Office of Vital Statistics, Public Health Service.

table 3, 44 percent of paralytic cases reported in the 1957 poliomyelitis surveillance program were in children under 5 years of age, compared with 42 percent in 1956, 32 percent in 1955, and 29 percent in 1952. This concentration of paralytic poliomyelitis in the preschool age group was observed throughout the Nation, although the tendency was more marked in southern regions.

In figure 4, age-specific attack rates for paralytic poliomyelitis in the United States during 1955, 1956, and 1957 are plotted on a logarithmic scale. During 1957, as in 1956, the highest age-specific rates occurred at 1 year of age, with a rapid decline thereafter to relatively stable rates beyond age 10. This pattern is in contrast with the experience during the previous 20 years (5), when attack rates in this country generally tended to remain high throughout the first decade.

The remarkable trough in paralytic poliomyelitis attack rates among children 7 and 8 years in 1955 has persisted in this cohort through 1956 (then 8 and 9 years of age) and

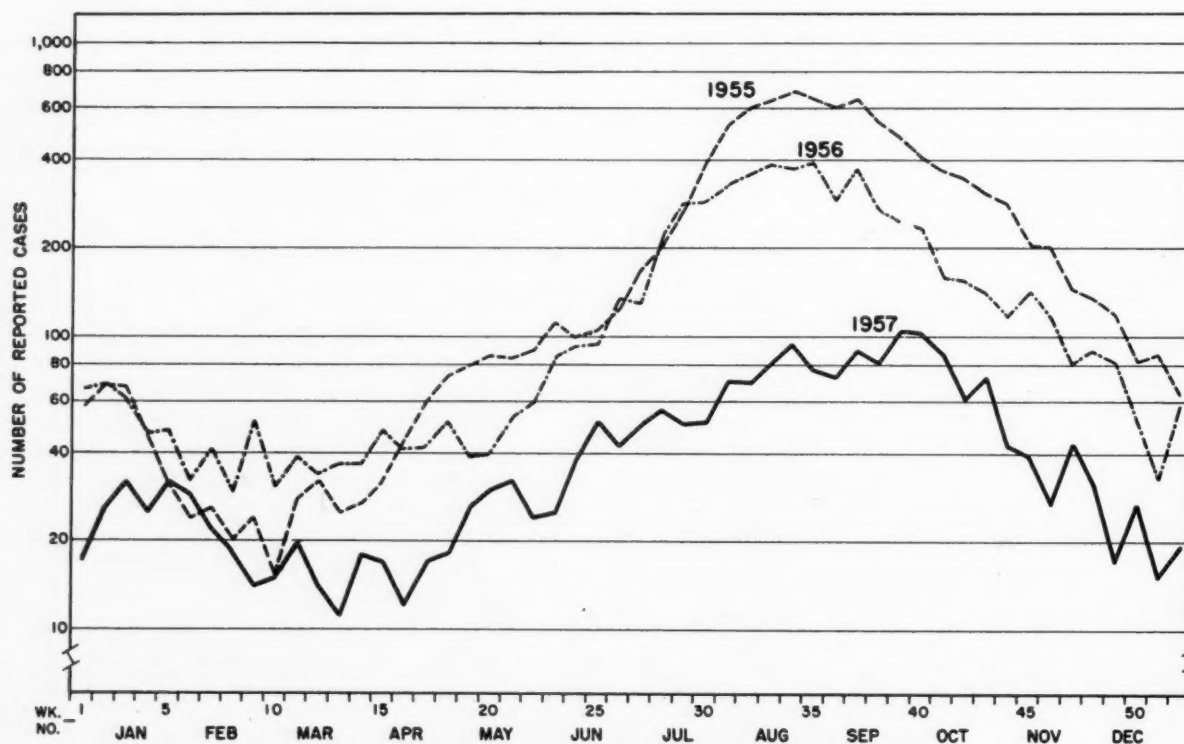
1957 when the lowest rates were among the 9- and 10-year-olds (fig. 4).

For nonparalytic poliomyelitis, in contrast with paralytic, the age distribution during 1957 was not appreciably changed from the pattern of 1952, 1955, and 1956 (table 3). The largest proportion of cases appeared in the 5- to 9-year age group, and the estimated age-specific attack rates for nonparalytic disease peaked approximately at ages 3 through 7.

Sex

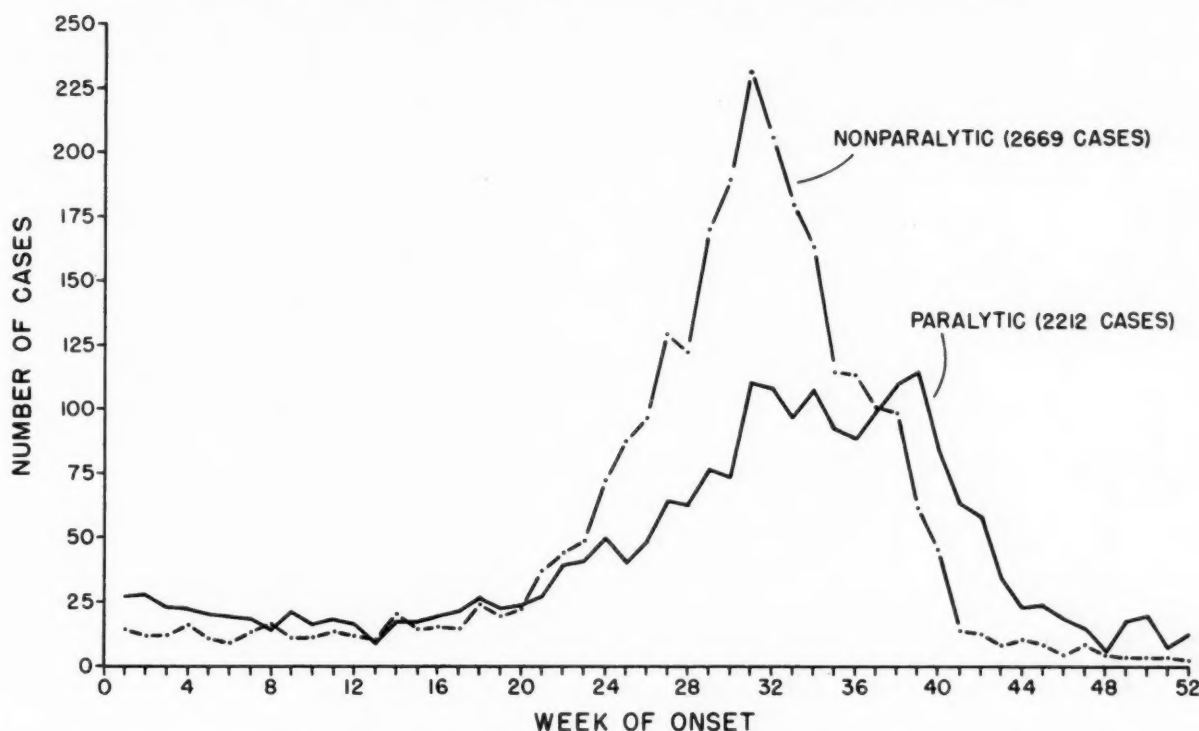
During 1957, just as in 1956 and in previous years, total poliomyelitis incidence in males exceeded that in females. In recent years, however, incidence in young adult females has tended to exceed that in males (3, 5). This pattern was seen in 1956 (4), when more cases occurred in females than in males at age 12 and ages 20 to 24. During 1957 the cases in females outnumbered the cases in males throughout the 20- to 40-year age group (table 4), but when corrections are made for the fact that the female population exceeds the male population

Figure 2. Paralytic poliomyelitis incidence in the United States, 1955-57.¹



¹ Data from the National Office of Vital Statistics, Public Health Service.

Figure 3. Seasonal incidence of poliomyelitis in the United States, 1957.¹



¹ Cases reported to the Poliomyelitis Surveillance Unit, Communicable Disease Center, Public Health Service.

in this age group, these differences are not so prominent.

Racial

Current age-specific attack rates cannot be derived by race since nationwide population estimates by race and age are not available beyond the 1950 census and since reporting of poliomyelitis by race is not a uniform practice.

Nevertheless, data from southern States and from several urban areas suggest that paralytic poliomyelitis attack rates in Negro populations are increasing both absolutely and relative to the rates in whites. Estimation of paralytic poliomyelitis attack rates by race in southern States in 1955 revealed the rate among whites to be 1.8 times that among nonwhites, while in 1957 the rate among whites was only 0.75 times that for nonwhites (6).

In the 1956 Chicago epidemic attack rates for paralytic poliomyelitis among Negroes were almost eight times those in whites (7,8). During 1957, the only large city with any concentration of poliomyelitis was Washington, D.C., where the paralytic attack rate in nonwhites was four

times as high as in whites. In 1956 and 1957, study of 14 additional urban areas reveals that 6 of these 14 experienced a similar increase in paralytic rates among nonwhites, in contrast with patterns of previous years. These areas were Philadelphia, Richmond, Norfolk, New York, Baltimore, and Atlanta.

Vaccination History

Evidence suggesting poliomyelitis vaccine effectiveness in the prevention of paralytic disease continued to accumulate during 1957. Table 5 presents by age group the proportion vaccinated of paralytic and nonparalytic cases reported during 1957 in the poliomyelitis surveillance program from 47 States and the District of Columbia. Since much of the nonparalytic illness was caused by nonpolioviruses against which the vaccine is ineffectual, it was expected that the proportion vaccinated among nonparalytics would be higher than among paralytics. This higher incidence among nonparalytics was observed in all age groups. An

Table 2. Poliomyelitis cases reported in 1956 and 1957 by State and paralytic status

State and region	1956					1957				
	Cases ¹			Rates ²		Cases ¹			Rates ²	
	Para-lytic	Non-para-lytic	Unspec-ified	Para-lytic	Non-para-lytic	Para-lytic	Non-para-lytic	Unspec-ified	Para-lytic	Non-para-lytic
United States	7, 911	6, 555	674	4. 7	3. 9	2, 499	2, 826	160	1. 5	1. 7
Northeast	684	680	66	1. 6	1. 6	192	213	-----	. 5	. 5
Maine.....	14	6	-----	1. 6	. 7	4	4	-----	. 4	. 4
New Hampshire.....	3	12	1	. 5	2. 1	1	10	-----	. 1	1. 3
Vermont.....	12	10	-----	3. 2	2. 7	4	1	-----	1. 1	. 3
Massachusetts.....	48	52	-----	1. 0	1. 1	11	14	-----	. 2	. 3
Rhode Island.....	2	7	-----	. 2	. 8	-----	-----	-----	-----	-----
Connecticut.....	30	53	-----	1. 3	2. 4	13	25	-----	. 6	1. 1
New York.....	384	369	1	2. 4	2. 3	107	89	-----	. 7	. 6
New Jersey.....	91	111	-----	1. 7	2. 1	29	52	-----	. 5	. 9
Pennsylvania.....	100	60	64	. 9	. 5	23	18	-----	. 2	. 2
North Central	2, 659	2, 827	267	5. 4	5. 7	713	1, 021	23	1. 4	2. 0
Ohio.....	313	262	3	3. 4	2. 9	122	101	6	1. 3	1. 1
Indiana.....	234	176	-----	5. 3	4. 0	87	73	-----	1. 9	1. 6
Illinois.....	1, 148	792	17	12. 2	8. 4	161	145	1	1. 7	1. 5
Michigan.....	308	348	-----	4. 1	4. 6	121	377	-----	1. 6	4. 8
Wisconsin.....	263	270	5	7. 0	7. 2	35	73	-----	. 9	1. 9
Minnesota.....	78	87	-----	2. 4	2. 7	34	32	-----	1. 0	1. 0
Iowa.....	45	491	44	1. 7	18. 2	21	57	-----	. 8	2. 0
Missouri.....	191	220	3	4. 5	5. 2	60	62	-----	1. 4	1. 5
North Dakota.....	13	27	1	2. 0	4. 1	7	7	3	1. 1	1. 1
South Dakota.....	8	28	1	1. 2	4. 0	18	14	10	2. 6	2. 0
Nebraska.....	58	126	8	4. 1	8. 9	29	45	3	2. 0	3. 1
Kansas.....	-----	-----	185	-----	-----	18	35	-----	. 8	1. 6
Northwest	295	239	18	4. 9	4. 0	66	41	12	1. 1	. 7
Montana.....	38	17	-----	6. 0	2. 7	5	5	2	. 8	. 8
Wyoming.....	18	17	1	5. 6	5. 3	7	5	-----	2. 2	1. 6
Idaho.....	63	31	16	10. 1	5. 0	6	7	10	. 9	1. 1
Washington.....	98	93	1	3. 7	3. 5	19	3	-----	. 7	. 1
Oregon.....	78	81	-----	4. 5	4. 7	29	21	-----	1. 6	1. 2
Southeast	997	849	98	3. 0	2. 5	621	506	71	1. 8	1. 5
Delaware.....	11	18	-----	2. 7	4. 5	1	4	-----	. 2	. 9
Maryland.....	90	23	-----	3. 2	. 8	33	7	-----	1. 1	. 2
District of Columbia.....	7	4	-----	. 8	. 5	66	9	-----	7. 9	1. 1
Virginia.....	151	86	-----	4. 1	2. 4	69	38	-----	1. 8	1. 0
West Virginia.....	60	48	5	3. 0	2. 4	39	18	-----	2. 0	. 9
North Carolina.....	179	136	-----	4. 0	3. 1	52	181	-----	1. 2	4. 0
South Carolina.....	46	67	-----	2. 0	2. 8	66	41	21	2. 8	1. 7
Georgia.....	101	85	1	2. 7	2. 3	71	10	12	1. 9	. 3
Florida.....	103	169	92	2. 7	4. 5	39	57	38	1. 0	1. 4
Kentucky.....	84	112	-----	2. 8	3. 7	68	39	-----	2. 2	1. 3
Tennessee.....	103	60	-----	3. 0	1. 7	68	92	-----	2. 0	2. 7
Alabama.....	62	41	-----	2. 0	1. 3	49	10	-----	1. 6	. 3
South Central	1, 573	1, 010	120	8. 7	5. 6	533	603	21	2. 9	3. 3
Mississippi.....	184	75	35	8. 7	3. 5	30	38	15	1. 4	1. 7
Arkansas.....	146	76	-----	8. 0	4. 2	25	25	-----	1. 4	1. 4
Louisiana.....	414	194	-----	13. 8	6. 5	74	95	-----	2. 4	3. 1
Oklahoma.....	93	94	33	4. 1	4. 2	35	80	6	1. 5	3. 5
Texas.....	736	571	52	8. 2	6. 4	369	365	-----	4. 0	4. 0
Southwest	1, 703	950	105	9. 5	5. 3	374	442	33	2. 0	2. 4
Colorado.....	87	68	3	5. 4	4. 2	26	22	1	1. 6	1. 3
New Mexico.....	37	21	26	4. 5	2. 6	19	10	21	2. 3	1. 2
Arizona.....	65	61	1	6. 1	5. 8	22	18	-----	1. 9	1. 6
Utah.....	145	24	58	17. 9	3. 0	12	10	11	1. 4	1. 2
Nevada.....	13	6	17	5. 3	2. 4	1	3	-----	. 4	1. 1
California.....	1, 356	770	-----	10. 1	5. 7	294	379	-----	2. 1	2. 7
Alaska.....	7	2	2	3. 3	1. 0	3	1	-----	1. 5	-----
Hawaii.....	45	17	-----	7. 7	2. 9	9	1	-----	1. 5	. 2
Puerto Rico.....	48	6	-----	2. 1	. 3	40	4	-----	1. 8	. 2

¹ Source: National Office of Vital Statistics, Morbidity and Mortality Weekly Report, vol. 5, No. 53, Oct. 23, 1957, and vol. 6, No. 53, Oct. 29, 1958.

² Rates per 100,000 population based on population estimates by the Bureau of the Census.

Table 3. Percentage distribution of paralytic and nonparalytic poliomyelitis cases by age group ¹ 1952,² 1955,² 1956,³ and 1957 ⁴

Age group, in years	Paralytic				Nonparalytic			
	1952	1955	1956	1957	1952	1955	1956	1957
0-4.....	29	32	42	44	21	19	21	17
5-9.....	25	21	16	18	31	29	26	28
10-14.....	13	12	11	9	16	17	16	16
15-19.....		7	7	6		8	10	11
20-29.....		16	15	13		16	18	18
30 and over.....	33	11	9	10	31	9	9	10
Total percent.....	100	99	100	100	99	98	100	100
Total cases.....	13, 552	9, 564	7, 399	2, 262	8, 321	8, 775	6, 269	2, 698

¹ Based on data reported to Poliomyelitis Surveillance Unit in the age distribution analysis. Cases in which paralytic status was not specified are excluded.

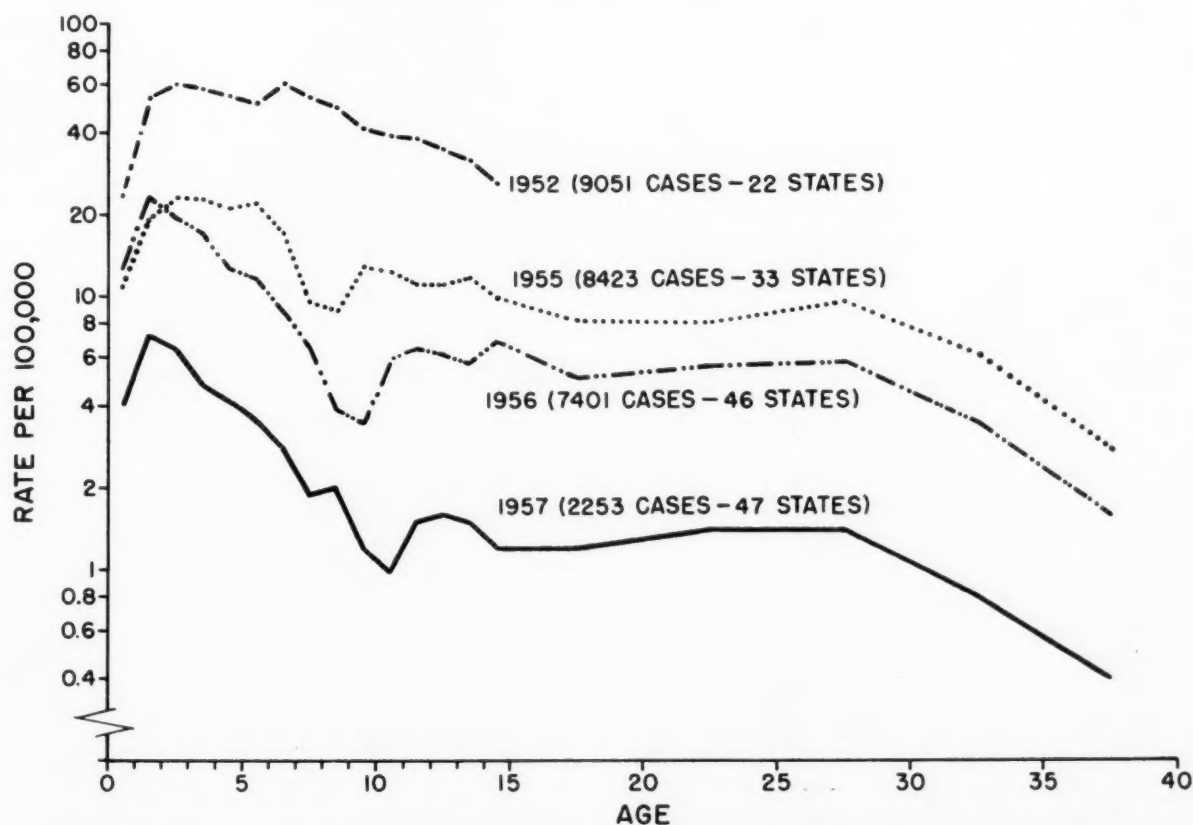
² 1952 data from 22 States and District of Columbia and 1955 data from 33 States and District of Columbia

previously presented in reference 3.

³ 1956 data from 45 States and District of Columbia, reference 4.

⁴ 1957 data from 47 States and District of Columbia.

Figure 4. Age-specific attack rates for paralytic poliomyelitis in the United States, 1952 and 1955-57.¹



¹ Cases reported to the Poliomyelitis Surveillance Unit, Communicable Disease Center, Public Health Service.

Table 4. Paralytic poliomyelitis cases in the United States in 1957, showing age distribution by sex ¹

Age group, in years	Males	Females
0-4	581	424
5-9	233	171
10-14	118	80
15-19	79	56
20-24	65	78
25-29	74	76
30-34	48	49
35-39	24	27
40 and over	42	26
Unknown	1	1
Total	1, 265	989

¹ Cases in which sex was unknown were omitted.

SOURCE: Data reported to Poliomyelitis Surveillance Unit from 47 States and the District of Columbia.

overall total of 54 percent of nonparalytic cases had received some vaccine as compared with 30 percent of paralytic cases.

The ability of the vaccine to modify the clinical characteristics of the disease is indicated in the correlation which exists between number of doses received and absence of paralysis. Whereas 56 percent of all nonvaccinated poliomyelitis cases were paralytic, only 25 percent of all triply vaccinated cases were reported paralytic.

Data obtained in August and November of 1957 for the Poliomyelitis Vaccine Activity Unit by NOVS through a supplement to the Census Bureau's Current Population Survey permitted an estimate of the vaccination status

of the United States population by age group. This analysis was under the direction of Dr. Monroe Sirken, chief, Actuarial Analysis Section, National Office of Vital Statistics. Using as numerators the vaccination history of cases of paralytic poliomyelitis reported by age groups in the poliomyelitis surveillance program and as denominators the above United States population estimates by age group and vaccination status, rough calculations of paralytic poliomyelitis attack rates were derived in vaccinated and unvaccinated populations. The estimated paralytic poliomyelitis rates were lower in the triply vaccinated than in the unvaccinated population (table 6). The percentage reduction ranged from 90 percent in the 0-4 year age group to 54 percent in the 20-29 year age group.

Such estimates represent uncontrolled comparisons of ratios rather than measured attack rates in controlled populations, and as such are subject to many potential errors. Such factors as variations in the vaccine status in different areas, ages, and population groups, and variations in the actual exposure to virus in individual groups should be taken into account in analyzing effectiveness of vaccine. Various studies are in progress at the present time to evaluate vaccine effectiveness in more controlled population subgroups.

Triply Vaccinated Cases

Cases occurring in triply vaccinated persons during 1957 included 207 paralytic, 588 nonparalytic, and 1 unspecified case. Of these, lab-

Table 5. Paralytic and nonparalytic poliomyelitis in the United States in 1957, by age group and vaccination history ¹

Age group, in years	Paralytic			Nonparalytic		
	Total cases	One or more doses	Percent vaccinated	Total cases	One or more doses	Percent vaccinated
0-4	970	246	25	434	212	49
5-9	394	198	50	742	550	74
10-14	198	93	47	417	311	75
15-19	132	37	28	293	125	43
20 and over	492	84	17	733	221	30
Total	2, 186	658	30	2, 619	1, 419	54

¹ Omitting cases in which vaccination status or age was not reported.

SOURCE: Data reported to Poliomyelitis Surveillance Unit from 47 States and the District of Columbia.

Table 6. Paralytic poliomyelitis cases¹ in the United States, 1957, attack rates among triply vaccinated and nonvaccinated persons, and estimates of vaccine effectiveness²

Age group, in years	Paralytic cases		Attack rates		Percent effectiveness
	Not vaccinated	3+ doses	Not vaccinated	3+ doses	
0-4	724	59	92.8	9.6	90
5-9	196	88	56.5	9.2	84
10-19	200	45	23.6	4.4	81
20-29	232	12	16.0	7.4	54
30-39	115	2	6.4	1.3	79
Total	1,467	206	28.2	7.1	75

¹ Cases reported to the Poliomyelitis Surveillance Unit.

² Population estimates of triply vaccinated and nonvaccinated persons provided by Dr. Monroe Sirken, chief, Actuarial Analysis Unit, NOVS, Public Health Service.

oratory data were reported on 85 paralytic cases and 171 nonparalytic cases (table 7). Studies were negative in the large majority of these cases; only 19 percent of the paralytic and 15 percent of the nonparalytic cases studied were confirmed as exhibiting current or recent infection with poliovirus, while other viruses were isolated in 10 percent of the paralytic cases and in 20 percent of nonparalytic cases.

Data regarding the extent of paralytic involvement remaining after convalescence were

Table 7. Poliomyelitis cases in triply vaccinated individuals in 1957, as indicated in laboratory studies

Type of disease	Paralytic		Nonparalytic	
	Cases	Percent of total tested	Cases	Percent of total tested
Poliomyelitis 1	6	7	11	6
Poliomyelitis 2			6	4
Poliomyelitis 3	10	12	7	4
Poliomyelitis, type unspecified			1	1
Coxsackie	6	7	15	9
ECHO	1	1	10	6
Unidentified virus	1	1	10	6
Negative	61	72	111	65
Total	85	100	171	101

SOURCE: Data reported to the Poliomyelitis Surveillance Unit from State and local health departments, from research laboratories, and from laboratories of the Virus Diagnostic Unit of the Communicable Disease Center, Public Health Service.

Table 8. Paralytic poliomyelitis cases in triply vaccinated individuals in the United States during 1957, showing severity of residual paralysis as indicated in laboratory studies

Estimated severity	Polio-virus isolated	Cox-sackie isolated	Nega-tive laboratory results	No labora-tory study	Total
Severe	17	1	15	19	42
Moderate	3	3	10	23	39
Mild	4		21	29	54
Total	14	4	46	71	135

¹ Including one fatality.

SOURCE: Data reported to the Poliomyelitis Surveillance Unit.

submitted by physicians in 135 cases (table 8). Residual paralysis was roughly estimated to be severe in 42 cases, moderate in 39, and mild in 54 cases. Of the severe cases poliovirus infection was confirmed in 7 and laboratory studies were negative in 15.

During 1957 three deaths from poliomyelitis were reported in triply vaccinated persons. Pathological findings were characteristic of acute poliomyelitis in one case from which type 3 poliovirus was isolated. In a second case, pathological findings were suggestive but laboratory studies were negative. The remaining fatal case was not confirmed; postmortem examination was not performed, and no material for virus isolation was available.

Vaccine Distribution

During the period April 1955 through December 1957, a cumulative total of 186.2 million cc. of net bottled poliomyelitis vaccine was distributed for domestic use. This total includes 27.7 million cc. shipped during the period April–December 1955, 70 million in 1956, and 88.2 million in 1957. In addition, 19.2 million cc. were exported during the period August 1956 to December 1957. During 1957, shipments lagged considerably behind releases, and a balance of 33.1 million cc. was cleared by the National Institutes of Health but not shipped by the end of the year. Distribution of vaccine by calendar quarters is presented in figure 5.

Vaccine Safety

Reporting of cases occurring within 30 days of a poliomyelitis vaccine inoculation was less thorough during 1957 than in 1955 and 1956. Analysis of 36 cases in 1957 with complete data revealed no tendency for the onset of illness to group in the 4- to 11-day period following inoculation. Onset of paralysis occurred in the inoculated limb in six cases and in the opposite uninoculated limb in four cases during 1957. No specific vaccine lot was known to be associated with more than three paralytic cases. The 1955 Cutter cases, in contrast, were associated with a small number of specific lots, and paralysis usually began in the inoculated limb 4 to 11 days following vaccination (1).

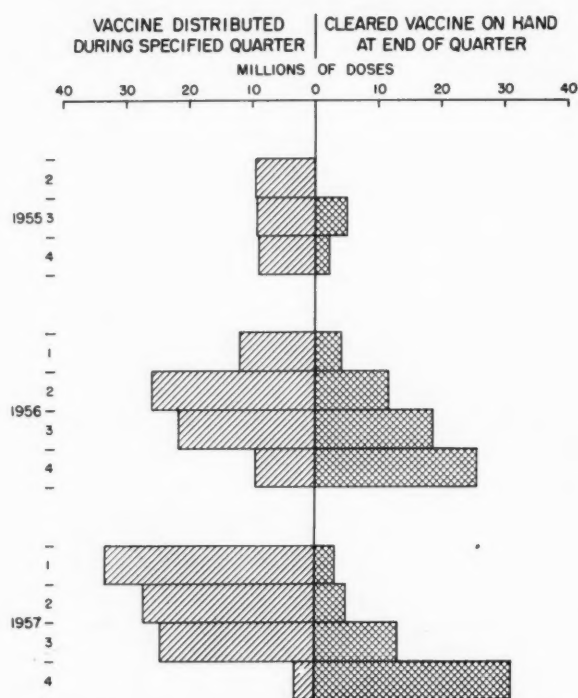
Discussion and Summary

Reported incidence of poliomyelitis in the United States during 1957 reached the lowest level since 1942. There were no major poliomyelitis outbreaks, and attack rates, particularly of paralytic disease, were low in all regions of the country.

Concurrently, during 1957 almost 90 million cc. of poliomyelitis vaccine were shipped in this country, bringing to over 180 million cc. the total vaccine distributed for domestic use since April 1955. More than half of our population has now received at least one dose of vaccine.

The extremely low incidence for paralytic poliomyelitis of 1.5 cases per 100,000 during 1957 is impressive in view of the extensive use of vaccine. However, marked annual variations have characterized poliomyelitis incidence

Figure 5. Poliomyelitis vaccine distribution, 1955–57.¹



¹ Data from Poliomyelitis Vaccine Activity Unit, Bureau of State Services, Public Health Service.

in this country in recent years. Furthermore, response to commercial poliomyelitis vaccine has been variable (9), and vaccinated subjects appear to be readily susceptible to gastrointestinal infection upon natural exposure to poliovirus (10–12). Therefore, it cannot be concluded that the widespread use of vaccine was alone responsible for the low total incidence of the disease during 1957. Final evaluation of the effect of inactivated poliomyelitis vaccine on poliovirus ecology and on total poliomyelitis incidence will require continued study over the next several years.

Changes in epidemiological patterns may nevertheless reflect the size and character of the vaccinated population since the Nation is not uniformly vaccinated. It has, therefore, become of increasing importance to continue detailed study of epidemiological trends of poliomyelitis in this country.

The striking change in age distribution pattern of paralytic disease observed during 1956 continued through 1957, with preschool children accounting for the largest proportion of cases

and with peak age-specific attack rates encountered in 1-year-old infants. Since the preschool ages were less thoroughly vaccinated than older children, it is probable that this change in the relative age distribution is at least in part a result of the vaccination programs. The trough in age-specific attack rates for paralytic poliomyelitis noted in 1955 among 7- and 8-year-olds and again in 1956 among 8- to 9-year-olds has persisted this year among the same cohort, now 9 and 10 years of age. Since this group in particular was thoroughly vaccinated in the school programs of 1955, the persistence of lowest paralytic attack rates in this population for 3 years suggests both effectiveness of the vaccine and duration of the induced immunity over the 3-year period.

Relatively and absolutely increased incidence of paralytic poliomyelitis was encountered during 1956 and 1957 among nonwhite racial groups in the south and in several metropolitan areas throughout the country.

Paralytic poliomyelitis cases tended to occur among unvaccinated individuals during 1957. Examination of vaccination history for paralytic cases in comparison with the estimated vaccination status of the United States population has permitted gross but reasonable estimations of paralytic attack rates in vaccinated and unvaccinated populations. The rate of paralytic disease in the triply vaccinated group was apparently reduced compared with that in unvaccinated populations. Further, a progressively lower incidence was recorded for those who had received 1, 2, or 3 doses of vaccine. These variations in calculations of effectiveness of three doses of vaccine reflect the unequal exposures of populations to virus and differing vaccination status of specific groups. The estimates are useful in determining the range rather than the specific degree of effectiveness.

Poliomyelitis vaccine shipments declined during the latter part of 1957. It is evident that increasingly active immunization programs will be required in order to achieve completion of the requisite three-dose schedule in large segments of the population as yet incompletely

vaccinated. Particular effort will be necessary in groups at relatively increasing risk, including the preschool ages and nonwhite populations.

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Youth is the period of building up the habits, hopes, and faiths. Not an hour but is trembling with destinies.—JOHN RUSKIN.

Federal Interest in Juvenile Delinquency

AIMS C. MCGUINNESS, M.D.

MANY American children grow up in a rough world. They come from homes broken by desertion, divorce, or separation, or are children of unwed mothers. These, generally, are the youngsters, deprived of a father's support, who are dependent upon the Federal-State aid to dependent children programs for the bare necessities of life. Throughout the Nation there are more than 2 million of these children.

There are many pressures. Thousands of children under 12 years of age, whose mothers work full time away from home, have no day-time afterschool supervision. There is no telling how many children live in undesirable neighborhoods with substandard housing. Every year millions of children change schools, moving from State to State, from town to town, or into different neighborhoods. Many children, of course, grow up in combinations of these unfortunate situations, these pressures.

And from their numbers come many of the disturbed children, the youngsters in conflict with the law, members of what has been called "the shookup generation."

Police currently handle more than 1.7 million cases of juvenile misbehavior a year. About a quarter of these, or 428,000, are referred to the juvenile courts by police; an additional 175,000

delinquency cases are referred to juvenile courts by parents, teachers, or social agencies, making a total of more than 600,000 delinquency court cases every year.

Their number grows. The delinquency cases handled by the juvenile courts increased by 137 percent between 1948 and 1957, whereas the child population from 10 to 17 years of age increased only 28 percent.

By 1965 there will be an estimated 30 million children in the United States in this high-risk, vulnerable age group, a third more than in 1957. If the incidence of juvenile delinquency continues to increase at the same rate as it has since 1948, then by 1965 the juvenile courts will be handling delinquent children at an annual rate of about a million cases. And by then, police will be handling a much greater number, many of which will never reach the courts.

There isn't any simple solution, as we all know. But we know, too, that juvenile delinquency has reached perilous proportions. Two things urgently need doing: first, we must arouse ourselves and our communities to get on with the job of doing those things that could and should be done now, and second, we must pursue with vigor the search for better understanding of the basic conditions which lead to this fearsome complex of social behavior.

Cooperative Efforts Needed

Successful efforts to combat juvenile delinquency require cooperation. It is a job for a number of people: the parents and relatives,

Dr. McGuinness is special assistant to the Secretary for Health and Medical Affairs, Department of Health, Education, and Welfare. He presented the full text of this paper before the Michigan Branch of the American Academy of Pediatrics in Detroit, March 10, 1959.

Standard Family Court Act

Family courts would take the place of separate juvenile and domestic relations courts in model State legislation developed by the National Probation and Parole Association in cooperation with the Children's Bureau, Department of Health, Education, and Welfare, and the National Council of Juvenile Court Judges.

The model legislation, entitled the "Standard Family Court Act," was published in April 1959, in the *Journal of the National Probation and Parole Association*, as the culmination of a 4-year project.

The need for a unified court approach to family problems has been indicated by various students of judicial procedure since early in this century. The new standard act represents a radical departure from previous model legislation by bringing together, under the jurisdiction of a single court, the major legal issues and problems of a personal nature which arise within families.

The family court, as proposed, would be set up on a statewide basis and would include a corps of specialized services within each court to treat such problems as delinquency and neglect, as well as provide special services in cases involving divorce, legal separation, support, adoptions, and certain criminal actions involving adults who commit offenses against children or other members within a family.

The new proposal, for the use and implementation by State legislatures, spells out the duties and responsibilities of the court as well as its relationship to other agencies. It sets up safeguards around the rights of parents and children in its provisions for legal counsel and in certain limitations it places on the court's procedures and disposition powers.

Specifically prohibited by the act would be transfer of a delinquent child to an institution for adult criminals; placement of a neglected child in an institution for delinquents; and subjecting a child to criminal court penalties and juvenile court control for the same offense.

The organizational pattern of the family court act would permit the establishment on a national basis of an accurate count of the number of children and families in trouble. Statewide reporting exists now in several States but not on a unified basis.

the doctor, the psychologist, the teacher, the social worker, the minister, the lawyer, and the police. And it is a job for citizens groups, voluntary organizations, and government at all levels, local, State, and Federal. The main work, of course, must be done in the communities, for troubled youngsters must be reached in person, in their homes, their churches, their schools, or on streets and back alleys, if that's where they are.

At the same time, juvenile delinquency is a matter of State and Federal concern. Because it is a highly complicated problem, many diversified approaches are required in its solution. In one way or another, it is of concern to virtually every unit of the Department of Health, Education, and Welfare.

The Children's Bureau, with responsibility for helping improve the conditions under which children are born and grow up, has a particular concern for those youngsters in conflict with society. In 1955 it established the Division of Juvenile Delinquency Services, whose staff members on request give professional consultation to juvenile courts, probation officers, police, youth commissions and councils, and citizens' organizations in cities and counties all over the country.

An important function of this unit is the development, in consultation with State and local authorities, of standards and guides for the use of professional personnel and agencies concerned with juvenile delinquency. A much-needed standard for the use of juvenile courts has been completed. In cooperation with the National Probation and Parole Association and the National Council of Juvenile Court Judges, the Children's Bureau is now working on a revision of the family and juvenile court acts.

As in the past, the Children's Bureau is the focal point in the Federal Government for initial planning of the White House Conference on Children and Youth. This historic conference, which has been called by the President of the United States in every decade in this century, will concern itself in 1960 with lasting values in the changing world. The problems of juvenile delinquency undoubtedly will have an important place in the program.

Between now and 1960, communities, States, and the Federal Government will be examining

how our changing world is affecting children. Specifically, study groups will explore such things as family, religion, and the arts. They also will look at community organizations and services as they impinge on the life of the child. In addition, they will inquire into the manner in which the behavior of adults, in their interactions with children and youth, deter or foster individual fulfillment and constructive services to humanity.

I am sure the many studies leading up to the conference will give us valuable new insights into the ultimate solution of juvenile delinquency prevention.

Prevention Main Objective

Prevention is the central objective of many other Federal activities that bear directly or indirectly on the question of juvenile delinquency. In 1956, the President called the first Conference on Fitness of American Youth, and subsequently created the President's Council on Youth Fitness and a Citizens' Advisory Committee to that council. For the past 2 years it has been my privilege to represent the Department of Health, Education, and Welfare on the Interagency Advisory Group to the Council.

The President has thus brought together many creative minds and new energies for a single purpose: to stimulate and encourage the building of men and women of physical, moral, and spiritual strength.

In the words of Homer C. Wadsworth, of Kansas City, chairman of the Citizens Advisory Committee, "The Council should serve three main purposes: (a) to continue to alert the American people to the need for special emphasis on the fitness of American youth; (b) to act as a clearinghouse for information on activities proven to be especially effective in this regard; and (c) to encourage a more effective coordination of public and private services in our communities designed to promote youth fitness."

These and other related activities are bound to bring enormous benefit to our children and young people. A really heartening advance was made for children when Congress last fall amended the Social Security Act to authorize the Children's Bureau to provide welfare serv-

ices for children in urban areas on the same basis as for rural children, services that will help to keep children in their homes and strengthen family life; that protect babies who are going to be adopted; that provide good foster homes when necessary; that help children in danger of becoming delinquent. This is the first time that Federal funds have been authorized to augment and strengthen local and State public and voluntary efforts.

In 1956, Congress amended the Social Security Act to give emphasis to social services in public assistance programs that lead, importantly, to the strengthening of family life and that help stimulate city and community efforts to help families and individuals get back on their feet and to tap all sources of help for families in trouble.

By incorporating in the legislation the word "services," Congress gave a powerful incentive to the States to move in the direction of prevention of human disasters that so frequently happen when a family undergoes a social breakdown. To move in the direction of helping people off assistance rather than helping people on assistance is the goal toward which all these programs must strive.

The Family Approach

The family approach to social problems is of real significance in the treatment of juvenile delinquency. Disturbed youngsters often come from disturbed families. And when we, as a Nation, are able to do a better job of reaching these multiproblem families, we will have come a long way in helping prevent juvenile delinquency and other social ills. Among the individual members of these families will be found not only juvenile delinquency but combinations of all the other problems that confront our society today: mental illness, physical disability, alcoholism, unmarried parenthood, broken homes, prostitution, drug addiction, and many others. These are the marginal families, dependent or potentially dependent. Their children are in "clear and present danger."

It should be emphasized that multiproblem families are not confined to low-income groups. There are probably as many multiproblem

families among the self-supporting as there are among families on public assistance. Problems of a family often first show up on hospital records, when an illegitimate baby is born or a mentally ill person is identified, or on police records, when a youngster comes in conflict with the law, or even on school records, when a child is consistently truant or an academic failure.

No one, of course, knows just how many of these families there are. But from a recent analysis of 25 cities based on records of official agencies, we get a rough idea of the number of families that have undergone a social breakdown. In half the cities the rate was 67 families per 1,000. Eastern and northern cities showed a rate between 29.4 and 78.3 families per 1,000. Southern cities had a uniformly higher rate.

These families are not all in hiding. Many are known to social agencies, teachers and the clergy, and members of our profession, and they are frequently known to the police. It makes sense to bend every effort to reach a family before it becomes dependent, or failing that, to help a swamped family get back on its own feet, emotionally and financially.

And that again is what the Department is trying to foster through its new emphasis on social work in the public assistance programs. This approach is gaining momentum all the time. But the full potential of public assistance programs will be approached only when all the resources of the community, public and private, that could possibly be of help to families in trouble are brought together in an organized way to bear upon immediate problems.

Program Interrelationship

In this and other programs of the Department, we seek to destroy the seeds of social evils before they have had a chance to germinate. The programs are interwoven, interrelated.

The Office of Education, alerted to the role that schools can play in identifying and helping delinquents or potential delinquents, has contracted with a number of universities and colleges for research studies on various aspects of juvenile delinquency in its relation to education.

One of the provisions of the new National

Defense Education Act should have an extremely beneficial effect in the prevention of juvenile delinquency. This is the title that sets up a nationwide system of testing, backed up by counseling and guidance programs. It seems to me that when special talents in boys and girls are identified when they are young, and when they are encouraged to pursue these talents and make the most of themselves, there will be a good deal less risk that they will become members of street gangs or get in trouble with the law. School counselors in many cases should be able to identify potentially delinquent children and bring community resources to bear on their problems in time to prevent real trouble.

The Public Health Service is intensifying its efforts in areas of mental health, with a number of significant programs relating to juvenile delinquency. Important fundamental work was done last year by scientists of the National Institute of Mental Health toward clarifying some of the basic mechanisms of psychological development and human behavior.

It is very encouraging to note the widespread expansion of community mental health programs. A high share of the cost of these programs is being provided by State and local resources. An alltime high of \$54 million was expended, from all sources, for these purposes during the past year, but only 7.4 percent of this represents Federal funds.

Delinquency In Perspective

I think, in any discussion of juvenile delinquency, we should put statistics in perspective. Not all of our children are growing up to be troublemakers. Most parents do a good job. Churches of all denominations have a large membership among children and young people. And our schools and numerous youth-serving organizations are doing a commendable job in promoting good citizenship.

But for those children who are delinquent, or likely to become so, we have an obligation to do what we can, when and where we can, and to start doing it now!

From its earliest days, our Nation has been a symbol of freedom to the rest of the world, freedom to stretch our minds in the way they incline, freedom of opportunity. Of the

world's 2½ billion people, somehow our Nation of 175 million has managed to accumulate almost half of the world's wealth.

We have the resources and much of the know-how to end hunger and scarcity and poverty and disease, and to slash out at social evils that have beset mankind through the ages. We have the resources to encourage more intellectual attainment among more young people. In our

own generation we could bring untold benefit not only to ourselves and our children, but to future generations of all people of the world.

Surely, amidst our plenty, we can realize the sheer practicality and find the resources of time, energy, money, and creative thinking to help these thousands of boys and girls in our society whom society, in some way, has failed and whom we have tagged "delinquent."

Protection of Dairy Products

As a result of developments such as the mass production of penicillin and of chlorinated hydrocarbon pesticides and the widespread use of these chemicals on the farm, interstate concern with milk has multiplied. In 1949, the Department of Agriculture joined the Food and Drug Administration in advising farmers that sprays containing DDT should not be used on milk cows or in dairy barns. These uses have largely been discontinued.

We have found that when a cow eats feed that contains DDT, she excretes the pesticide in her milk. Most of the other chlorinated hydrocarbons also leave poisonous residues in milk when used on the cow or her feed.

When penicillin is infused into the cow's udder to treat mastitis, it comes out in the milk for a considerable period of time. Some farmers are using chlorinated hydrocarbons and penicillin improperly and residues of these chemicals are showing up in milk. Although the residues are very small, they cannot be tolerated.

Our limited surveys of milk conducted in 1954 and 1955 disclosed that 3 percent of the 1954 samples and more than 11 percent of the 1955 samples contained minute quantities of penicillin. A larger survey in 1956 covering the entire country showed similar penicillin residues in about 6 percent of the samples.

In our nationwide survey of market milk for pesticide residues in 1955, quantitative chemical tests on 169 samples believed to have

highest insecticide residues (based on earlier bioassay) showed 33 samples with residues ranging from 0.05 to 1.5 ppm of DDT, or its equivalent.

Remedial steps we have taken since then include the requirement that penicillin-containing drugs for treating mastitis by infusion into the cow's udder must bear a warning on the label itself that milk from treated cows should not be used as food for 72 hours after the treatment; formerly, this warning might appear only on the circular shipped with the drug. The penicillin content of mastitis treatments is now limited to 100,000 units per dose; formerly much larger amounts were being used.

A recent nationwide survey gave the following preliminary findings:

- Around 0.1 ppm of chlorinated hydrocarbons by chemical tests in about 4 percent of almost 800 market milk samples tested. The more sensitive bioassay shows a higher percentage of samples with residues.

- Penicillin residues in 3½ percent of more than 1,100 samples tested. When the positive samples were averaged, the penicillin content was approximately 0.1 unit per milliliter of milk. (These percentage figures are not strictly comparable with those obtained earlier because of some variation in sampling procedures.)

It is clear that there has been significant improvement in the milk supply. This reflects sincere, extensive efforts.

—Excerpt from a speech delivered by George P. Larrick, Commissioner of Food and Drugs, at the Dairy Products Improvement Institute in New York City, February 19, 1959.

Although automobile exhaust contains dozens of compounds, only a limited number of these are a potential public health hazard.

Health Hazards of Automobile Exhaust

JOHN R. GOLDSMITH, M.D., M.P.H., and LEWIS H. ROGERS, Ph.D.

THE GASES, vapors, and particles in automobile exhaust are considered by many to be the major contributing factors of Los Angeles' air pollution, which is so strikingly characterized by irritation of the eyes (1,2). Other west coast cities, including San Diego and San Francisco, appear to have a similar problem in less severe form. We have learned that when the nitrogen oxides and partly burned fuel of automobile exhaust are irradiated the characteristic photochemical type of smog is produced (3). Concern regarding this form of air pollution derives both from the widespread symptoms and from the possibility of immediate or long-term effects on health (4). If attention is focused on hydrocarbons and nitrogen oxides, in an effort to abate eye irritation, other adverse effects of automobile exhaust may unfortunately be ignored. This review attempts to place these other effects in perspective.

When only a few automobiles are driven on country roads, there is no public health problem, but when thousands of cars are operated in a small area with a limited supply of fresh air, automobile exhaust may constitute a potential hazard to the health of the community. This will be true even in the absence of irritated eyes and reduced visibility, so characteristic of photochemical smog.

Dr. Goldsmith is head of studies of health effects of air pollution, California State Department of Public Health, Berkeley, and Dr. Rogers is associate director, Vitro Laboratories, West Orange, N.J., and formerly senior chemist, Air Pollution Foundation, San Marino, Calif.

The solution of two imperative questions lies in the future: How much exhaust can be tolerated in how much air? When does this potential hazard become an actual one? For the present, we shall concern ourselves with what is known about the constituents of automobile exhaust and with an approach to answering these questions.

Composition of Automobile Exhaust

We are confining our attention to air pollution from spark-fired internal combustion engines and excluding that from diesel engines. In most urban areas, the latter, although sometimes a local nuisance, is of lesser importance to the community. In Los Angeles, for example, the air pollution from diesel engine exhaust is about 20 tons of organic emissions per day, whereas auto exhaust contributes about 1,200 tons of organic emissions per day (5).

When a petroleum fuel is completely burned, the products are carbon dioxide and water, together with nitrogen and unused oxygen from the air. However, in a spark-fired internal combustion engine some of the nitrogen is also oxidized producing the several oxides of nitrogen. In automobiles the ratio of air to fuel is seldom maintained at the theoretical value of 15:1 required for complete combustion. More frequently, this ratio amounts to about 12:1 at idling and 13.5:1 at cruising.

Under these conditions, other products appear in the exhaust, including carbon monoxide, hydrogen, aldehydes, and unburned hydrocarbons. In addition, oxides of sulfur occur in

exhaust depending on the amount of sulfur in the fuel, and lead compounds are present in a form determined by the additives used in the fuel. Because of tremendous differences in operating conditions, condition of cars, and other factors, it is difficult to give representative analyses. Some characteristic ranges of exhaust gas composition are presented in table 1. Of the constituents listed in table 1, we shall consider only hydrocarbons, oxides of nitrogen, lead compounds, and carbon monoxide.

Effects of Time and Weather

Since the composition of exhaust gas is so variable and is quickly diluted several hundred-fold when it is released to the atmosphere, knowing the actual concentrations of exhausted gases in the atmosphere is important. These concentrations are affected by windspeed, presence and intensity of a temperature inversion, vehicle operating conditions, number of automobiles operating per square mile, and further reactions of the atmospheric constituents. To illustrate how high the concentrations may become, table 2 shows values of hydrocarbons and carbon monoxide at five busy intersections in Los Angeles during peak traffic and adverse weather conditions.

About 5,000 vehicles per hour passed the intersections at which the samples were taken except at Hollywood and Harbor Freeways, where about 11,000 per hour passed.

Community and Industrial Exposure Hazards

The substances listed in table 1 have been subject to conventional toxicological studies, especially from the viewpoint of occupational hazards (9-11). Although the toxicological procedures are well established there are several reasons why this approach is inadequate for our purposes.

Industrial exposure standards are usually determined by the American Conference of Governmental Industrial Hygienists. These standards, called "threshold limits," are based upon exposures of healthy adults to a single substance for a period not to exceed 8 hours followed by a recovery period of at least twice that long. In community air pollution from auto-

mobile exhaust, concentrations vary from hour to hour, but the exposure may be continuous, both in time and, for most persons, in place. Coming home from work does not mean an end of exposure to air pollution and may mean a great increase if the trip requires driving during peak traffic.

The extent to which exposure to one or more of the substances in automobile exhaust increases the effect of another is not known. Concern over this possibility is heightened by some examples of synergistic effects. Amdur (12) has shown the extent to which aerosols enhance the effects of SO₂ on the pulmonary airway flow resistance in guinea pigs, and Falk (13) has shown the effect of soots on deposition of carcinogens. Until further studies have clarified such interactions, it is necessary to suspect that components of exhaust may have synergistic effects.

While industrial exposures usually involve small numbers of relatively healthy people, community exposures affect, in varying ways, the entire population of a community, the sick with the well, the frail with the vigorous. In sufficient concentrations, exhaust from automobiles may lead to morbidity or even mortality in the sick and frail segment of the population whereas the same exposure might not noticeably affect healthy and vigorous persons. For persons with circulatory failure or with reduced competence of cerebral or myocardial circula-

Table 1. Composition of automobile exhaust

Constituent	Percent of concentration (volume/volume)	
	Minimum	Maximum
Aldehydes.....	0	0.03
Carbon dioxide.....	5	15
Carbon monoxide.....	0.2	12
Hydrocarbons.....	0.01	2
Hydrogen.....	0	4
Lead compounds.....	(1)	(1)
Nitrogen.....	78	85
Oxides of nitrogen.....	0	0.4
Oxygen.....	0	4
Sulfur dioxide.....	(2)	(2)
Water vapor.....	5	15

¹ Depends on lead additives.

² Depends on sulfur content of fuel.

SOURCE: References 6 and 7.

Table 2. Carbon monoxide and hydrocarbons in Los Angeles, Calif., near traffic arteries for days with low-level thermal inversion conditions,¹ September 1956²

Street intersection	Carbon monoxide (ppm)		Hydrocarbons (ppm)		Number of samples	Days of sampling
	Maximum	Mean	Maximum	Mean		
Slauson at Figueroa.....	93.2	30.2	2.33	1.32	54	3
La Brea at Olympic.....	65.2	34.4	1.74	1.10	18	1
San Fernando at Highland.....	41.7	15.4	1.56	.76	36	2
Hollywood and Harbor Freeways.....	64.1	36.0	1.83	1.24	36	2
Vineand and Ventura.....	48.5	30.8	1.50	.94	36	2

¹ Low-level thermal inversion conditions refer to that condition in the atmosphere when the upper level of air over the earth, instead of being colder than the surface air, is warmer, thereby trapping the air beneath it.

² Average of 6 samples taken every 30 minutes between 6:00 and 8:30 a.m., Pacific Daylight Saving Time, at 3 distances from the curb.

SOURCE: Reference 8.

tion, slight impairment of the oxygen transport function of the blood may have serious consequences. In addition to these people, two other groups are at unusual risk from communitywide exposure to auto exhaust. They are the workmen who experience a similar type of exposure while employed, and persons who inhale tobacco smoke. If a member of these multiple exposure groups is also ill, or has impaired health, then the hazard may be compounded.

Finally, we cannot assume that termination of exposure terminates risk of ill effects. In this connection, data on lung cancer reported in Eastcott's study of emigrants from Great Britain to New Zealand are revealing (14). He found that the duration of exposure to urban air pollution in Britain before emigration was significantly associated with rates of development of lung cancer observed many years later. Since cigarette consumption was similar in Great Britain and New Zealand, the evidence points toward atmospheric pollution as a factor in the causation of the disease.

It will take years to estimate accurately the possible delayed consequences of exposure of large numbers of persons to automobile exhaust fumes, but the possibility of harm exists and is difficult to evaluate by conventional toxicological methods.

Carbon Monoxide

The maximum carbon monoxide concentration reported in table 2 is 93.2 ppm, while the

average values were 15 to 36 ppm. Average concentrations of 4 to 20 ppm, with a maximum of 80 ppm, have been reported in British cities during smog (15). Similarly, an average of 28.9 ppm carbon monoxide in Detroit during heavy traffic has been reported, with a maximum of 80 ppm (16).

More is known about the mechanism of absorption and action of carbon monoxide than about any other noxious substances found in exhaust. This tasteless, odorless, colorless gas is 250 times as firmly bound to hemoglobin as is oxygen. It may be calculated that at equilibrium for every part per million of carbon monoxide reaching the lung, 0.16 percent of the body's hemoglobin is combined with carbon monoxide, and hence inactive. Roughton (17) has shown further that in the presence of carbon monoxide-hemoglobin compounds, oxygen is bound more firmly to hemoglobin, thus further impairing oxygen transport.

While no health damage has been attributed to carbon monoxide exposures below 100 ppm, the presumption that such levels inactivate a small amount of hemoglobin is inescapable. Gaensler and his associates (18) have shown that urban nonsmokers have a CO level corresponding to saturation of 0.62 to 1.24 percent of hemoglobin, while smokers have 3.1 to 7.8 percent. The public health importance of this lies in the certainty that smoking and exposure to automobile exhaust are so common that a very large number of persons are affected in such a way that up to 8 percent of their hemo-

globin is unavailable for oxygen transfer. Accurate predictions of carbon monoxide-hemoglobin levels from environmental measurements are complicated by the fact that some time is taken to reach equilibrium and this time varies with the activity of the subject.

In studies on the adaptation of eyes to darkness McFarland (19) demonstrated an impaired adaptability in older persons which was duplicated in young subjects when breathing gases deficient in oxygen or when exposed to low levels of carbon monoxide. The importance to automobile drivers of visual sensitivity at night is obvious. However, it has not been shown that exposure to automobile exhaust at the levels found on the freeways of a modern city impairs the adaptability of eyes to darkness or alters the exchange of vital respiratory gases, although this is a plausible inference.

Some idea of the possible exposures of drivers is obtained by sampling air in the driver's compartment of motor vehicles, as shown in table 3 (20).

Another way of stating the effect of carbon monoxide is that its inactivation of hemoglobin is similar to withdrawing the corresponding amount of blood from circulation. From this viewpoint a concentration of carbon monoxide of 100 ppm, when equilibrated, is associated with inactivation of about one-sixth of the body's circulating hemoglobin, equivalent in volume to about one pint of blood, with corresponding loss for other concentrations of carbon monoxide.

Nitrogen Oxides

During acceleration and cruising, automobiles emit appreciable quantities of nitric oxide. On mixing with oxygen, nitric oxide is oxidized to nitrogen dioxide, so that a mixture of these two oxides is found in the atmosphere. The concentration of nitrogen oxides in the open air may be 1 ppm at times when CO is 50 ppm.

The toxicity of nitrogen dioxide is based on its irritant properties, often delayed in onset. In cases of significant exposure, signs and symptoms of pulmonary edema have been noted hours to days later (21). Nitric oxide also forms a stable compound with hemoglobin in vitro, which, if it occurred in vivo, would make

the hemoglobin unavailable for transport of carbon dioxide and oxygen.

Nitrogen dioxide on dissolving forms some nitrite ion which is capable of reacting with hemoglobin to yield methemoglobin, also unsuitable for transporting respiratory gases. That this may occur under some circumstances is suggested by a report of methemoglobin levels of 2.3 to 2.6 percent in welders exposed to a mixture of gases including nitrogen oxides (22).

It is unlikely that toxic effects would occur solely from the levels of nitrogen oxides found in places with air pollution due to automobile exhaust. But the similar effect of the reaction of hemoglobin with carbon monoxide and with nitrogen oxides lends greater significance to studying the latter.

Lead Compounds

Nearly all gasoline used in automobiles contains lead tetraethyl, up to as much as 3 ml. per gallon. This lead is mostly discharged through the exhaust to the atmosphere, and this fact has caused much concern over the past 25 years as to the possible effects of lead on health. Lead occurs mostly in the particulate form, and a maximum concentration of 16 micrograms per cubic meter has been reported by Cholak and others in Los Angeles with average values of 7 micrograms per cubic meter (23) during a 4-month period, August–November 1954.

In general, analyses of urban air show lead concentrations which are low in relation to the amount of lead burned in gasoline. This may

Table 3. Levels of carbon monoxide in parts per million found in compartments of drivers of motor vehicles in California

Parts per million	Number of vehicles	Percent of vehicles
0-49	1, 014	91. 8
50-99	69	6. 2
100-149	13	1. 2
150-199	5	. 4
200-249	1	. 1
250-299	2	. 2
600-649	1	. 1
Total	1, 105	100. 0

be explained by the fact that the particle size of the exhausted lead ranges from 0.01 micron to several millimeters in diameter, and the large particles can be expected to settle rapidly when exhausted into open air. Moreover, high-speed driving tends to increase the number of heavy particles, and also tends to clean out the exhaust system of lead previously deposited during the light duty, stop-and-go driving conditions (24).

Estimating the retention of lead in the body is complicated by the problem of particle size and composition. Generally speaking the smaller (submicron) particles impinge on the deeper portions of the lung, where they may be rapidly absorbed, while larger particles are more likely to impinge on the mucous layer of the upper portion of the airway and subsequently be swallowed. Such a route is associated with loss of most of the lead in the feces.

One feature of the toxicology of lead indicates that its effect might be related to that of carbon monoxide and of nitric oxides. In chronic lead poisoning, there is found a low-grade anemia and also increased fragility of red blood cells; this may tend indirectly to impair transportation of respiratory gases.

When considered apart, lead exposure from observed levels in Los Angeles and other cities is not toxic, but lead exposures are so common in industry and in garages that the small and persistent increment in exposure associated with auto exhaust may be sufficient to render an otherwise tolerable lead burden a toxic one in a few persons.

Hydrocarbons

Although "hydrocarbons" have been classed as a group in table 2, it is apparent that the group includes many compounds such as paraffins, olefins, aromatics, cycloparaffins, and others. The particular mixture in automobile exhaust depends in part on the fuel used and in part on the way the motor vehicles are operated. The total hydrocarbon concentration in the open air seldom exceeds 2 ppm, hence the concentration of individual compounds will be much less than that. At these low concentrations, only those having known physiological activity are of concern.

One group of hydrocarbons of particular interest includes such compounds as 3,4-benzpyrene which under experimental conditions may produce cancer in animals. This compound, along with others of similar chemical constitution, has been qualitatively identified in automobile exhaust in trace amounts (25,26). Although polynuclear hydrocarbons produce tumors when painted on the skin of susceptible animals, their inhalation has resulted in no experimental lung cancers. Experimental tumors can be produced if the lung's mucosa is damaged, for example, by a transfixion suture soaked in the carcinogen or by a hooked capsule containing the substance which is retained in the bronchus of an experimental animal (27). From such studies one is led to the hypothesis that carcinogenesis occurs on the basis of damage to the mechanisms protecting the underlying tissues.

The possibility that these trace quantities do in fact have a relation to the occurrence of lung cancer is a debatable point, and one on which additional research is necessary. Moreover, even if 3,4-benzpyrene is a cause of lung cancer, it is present to a much greater extent in coal smoke than in automobile exhaust. Communities in which coal is used as a major fuel could expect to find far more 3,4-benzpyrene arising from coal burning than from combustion of petroleum fuels. For example, Los Angeles (28), where no coal is burned, has been found to have 3.3 micrograms of 3,4-benzpyrene per 100 cubic meters of air, while in London (29) values up to 47 micrograms per 100 cubic meters have been reported.

Interactions of Exhaust Components

On the west coast, where weather conditions may lead to poor dispersal of automobile exhaust, and where there is an abundance of solar radiation, an interaction of nitrogen oxides and hydrocarbons occurs. This results in the obnoxious mixture which we call photochemical smog. The principal products are ozone and organic intermediates, some of which irritate eyes and damage plants. Ozone sometimes reaches a concentration of 0.5 ppm or more.

It is known that ozone is a highly irritating

substance, and is capable of producing clinical signs of pulmonary irritation. Repeated daily exposures of animals to 1.0 ppm for about a year produced fibrosis of the lung in some species. Recently the hygienic standard for industrial exposure was reduced from 1.0 ppm to 0.1 ppm by the American Conference of Governmental Industrial Hygienists.

Of all the substances mentioned, ozone is the only one in Los Angeles which exceeds the hygienic standard for industrial exposure of 0.1 ppm. However, studies to determine whether respiratory disease or deaths in Los Angeles are more common on days with high air pollution levels have not so far demonstrated such an effect. In a review of the hazards of ozone, Stokinger (30) states that "if the response of the human lung to ozone may be assumed to be similar to that of the animals tested in these studies, one might reasonably conclude that no acute effects on human beings would be expected from ozone exposures occurring in Los Angeles-type smog, owing to the often repeated exposures to very low grade ozone concentrations of the order of a few tenths part per million." Nevertheless, the use of pulmonary function tests on large numbers of persons may assist in reaching a conclusion about the effect of ozone or other irritants on respiratory function.

In addition to ozone, reactive organic intermediates, including free radicals, are formed (31). Whatever the compounds may be that cause eye irritation, it has been proved that these compounds are produced by irradiation of automobile exhaust.

It remains to be shown, however, whether the same compounds irritate the respiratory tract or whether irritation by inhaled substances plus inhaled carcinogens could produce cancer of the lung. More data are needed on the exact nature of the reactions, the concentration of the products, and their physiological effects.

Discussion

Two important effects of the known constituents of automobile exhaust are (a) the conversion of hemoglobin into a relatively stable, inactive form which impairs the efficiency of the blood and circulation in transporting the respiratory gases, oxygen and carbon dioxide, and

(b) the production of respiratory tract irritation or pulmonary edema, either of which interferes with the transport of gases between the blood and the external atmosphere. The severity of both of these effects on individuals would depend on concentrations, length of exposure, age and vigor of the subjects, and other conditions. Concentrations found in the Los Angeles atmosphere have not been shown to interfere with gas transport mechanisms.

We have described what seems to be a potential hazard. To demonstrate whether an actual hazard exists, it will be necessary to combine measurements of exhaust constituents in the atmosphere with estimates of the impairment they produce. For example, measurements should be made of the proportion of hemoglobin inactivated by carbon monoxide and nitric oxides in large numbers of persons exposed to air polluted by automobile exhaust.

We suggest that hygienic standards for automobile exhaust in a community should be set at levels which will produce no health effects on the most susceptible group of persons in the community, defined in terms of age or health status. Among the groups to be considered would be those ill with impaired cerebral or myocardial circulation or impaired pulmonary function.

It is of interest that the public health problems of automobile exhaust have been recently surveyed in the U.S.S.R. with essentially the same conclusions as were independently reached by us (32).

Despite the difficulties, all possible means should be taken to control atmospheric pollution from automobile exhaust. At present it seems unlikely that control devices for automobile exhaust will eliminate all of the potentially harmful substances. Until there is complete control, potential hazards should be recognized and efforts made to assess damage.

Summary

Of the substances which occur in automobile exhaust and their reaction products, hygienic standards have been established for industrial exposure to carbon monoxide, nitrogen dioxide, lead, and ozone. Establishing a full set of levels for community exposures to these sub-

stances is very difficult because of the sensitivity of frail or ill individuals, the indeterminate period of exposure, the effect of agents in combination, and the cumulative effect of exposure from other sources, such as cigarette smoking.

The hazard of automobile exhaust to the population of a large community will depend, among other things, on the extent and way that vehicles are used, and the meteorology of the area.

In the absence of effective control for air pollution from automobile exhaust, the public health hazard should be evaluated.

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Stebbins New Chairman of PHR Board of Editors

Dr. Ernest Lyman Stebbins, dean of the Johns Hopkins University School of Hygiene and Public Health for the past 13 years, is the newly appointed chairman of the Board of Editors of *Public Health Reports*. He succeeds Dr. Edward G. McGavran, dean of the University of North Carolina School of Public Health, who has served as chairman since 1952.



Dr. Stebbins entered the public health field in 1931 as an epidemiologist with the Virginia State Department of Health after completing internship and residencies at Clara Barton Hospital in Los Angeles and Presbyterian Hospital and the University Clinic in Chicago.

In 1934, he transferred to the New York State Department of Health and was appointed New York City Health Commissioner in 1942. In 1945, he received the Lincoln Award for distinguished service to the city. From 1940 to 1946 he was a professor of epidemiology at Columbia University.

He served as a medical director with the Public Health Service during the war and retains status as a reserve officer.

Dr. Stebbins is a fellow of the American Medical Association and the American Public Health Association; 1958-59 president of the Advisory Board of Medical Specialties; chairman, American Board of Preventive Medicine; and former president of the American Epidemiological Society.

Publications by Dr. Stebbins include, in addition to reports of scientific research, "Epidemiology and Social Medicine—Social Medicine: Its Derivations and Objectives," Commonwealth Fund, 1949, and "Introduction to Public Health," written with Dr. Harry S. Mustard.

After being graduated by Dartmouth College in 1926, Dr. Stebbins received his medical degree from the Rush Medical School of the University of Chicago in 1929. His master's degree in public health was earned at Johns Hopkins University School of Hygiene and Public Health in 1931.

A Baseline Survey Of Pennsylvania Sanitarians And Their Backgrounds

HENRY R. O'BRIEN, M.D., M.P.H.

IN the late spring of 1956, an investigation of the background of sanitarians, which began in Maryland and Puerto Rico in 1954 (1), was extended to Pennsylvania. On both occasions, a training program was in progress. It was felt that the development of further plans would be aided by a knowledge of the situation, in particular, the number of sanitarians, their ages, educational background, salary, length of service, and so on.

The same questionnaire was used in 1956 as in 1954. The blanks were circulated by the divisions of sanitation in Philadelphia and Pittsburgh and by our regional sanitarians to State employees and full-time local sanitarians. In these groups the coverage was practically complete; the one or two local sanitarians who may have been overlooked would not invalidate the findings. In private industry, however, only a beginning was made; this is practically a dip sample.

In most places in the United States, certainly in Pennsylvania, three groups are providing environmental health service: the sanitary or public health engineer at the top, a sanitary inspector in the ranks, usually local, and a new person, the sanitarian, who has now appeared between the other two. The third group is growing in numbers, training, and functions; the second is probably shrinking.

The changes are so rapid that it is valuable to have a record of this study as a baseline, not only as a help in planning training but also for later comparison to measure progress. Many new people are being appointed, with much

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more training, to work on new programs or on old programs in new ways. Many of these 1956 findings no longer obtain, but it is essential to have them on record or we shall not know in 1961 or 1966 just how far we have progressed.

This paper considers the "sanitarian" and the "sanitary inspector" together, for the borderline is not yet definite. Staff members and their supervisors are included, but not (a) those with engineering degrees or those doing strictly engineering work, (b) veterinarians concerned with diagnosis or treatment of sick animals, (c) employees of other State departments, (d) Federal workers, (e) laboratory technicians, or (f) laborers.

In all, 312 replies to the questionnaire were received and tabulated, including 91 from the State, 51 from Philadelphia, 43 from Pittsburgh, 107 from smaller local departments of health, and 20 from private industry. Next to public health nurses, sanitarians make up the largest group in public health in Pennsylvania.

Some of the findings of the questionnaire are included in the tables and discussion below. The conclusions from these data are limited in scope, for the questions are few and the numbers are small. However, trends are evident.

Population Ratio

First, we may ask the number of sanitarians employed by health departments in relation to 1956 population estimates. In Pittsburgh, 1 sanitarian was at work per 15,700 persons in the population. In Philadelphia, the ratio was 1 to 42,700 and in the rest of Pennsylvania, counting both State and local sanitarians, 1 to 42,000. In Baltimore and Puerto Rico in 1954, on the other hand, the figure was 1 to 10,000 and in upstate Maryland 1 to 20,000. These proportions are enough to make us consider whether in much of Pennsylvania sanitarians are too few, although they do not reflect the number of sanitarians in private employment, the level of sanitation practice, or the effects of climate or dispersion of population.

Age, Education, and Salary

The age and education of Pennsylvania's sanitarians are shown in table 1. The median

figure for the first college degree is in the 30-34 age group. Those with two degrees are naturally a little older. The median figure for those

with no more than a high school background is at still an older age (45-49), and for those with only grade school, older yet (60-64). These

Table 1. Relationship of age and highest education attained by Pennsylvania sanitarians, 1956

Age group	Second college degree	First college degree	High school graduate	Some high school	8th grade school or less	Total
24 and under.....	0	8	2	0	0	10
25-29.....	1	26	7	0	0	34
30-34.....	8	22	11	0	1	42
35-39.....	2	8	19	2	0	31
40-44.....	4	5	18	3	3	33
45-49.....	3	5	15	5	3	31
50-54.....	3	2	18	10	3	¹ 37
55-59.....	1	2	9	12	4	28
60-64.....	1	0	10	5	6	22
65-69.....	1	1	5	6	7	20
70-74.....	1	0	5	3	3	12
75-79.....	0	0	3	2	2	7
80-84.....	0	0	1	0	2	3
Not stated.....	0	0	2	0	0	3
Total.....	25	79	125	48	34	312

¹ Educational level not given for 1 person.

NOTE: Boldface numbers represent the age group near which the median number falls.

Table 2. Educational progress of all Pennsylvania sanitarians in areas studied, 1956

Schooling completed	Total	State	Philadelphia	Pittsburgh	Local	Industrial
All sanitarians						
Total number.....	312	91	51	43	107	20
8th grade:						
Number.....	304	91	50	42	101	20
Percent of total.....	97. 4	100	98. 8	97. 7	94. 4	100. 0
High school:						
Number.....	¹ 229	70	42	32	67	18
Percent of total.....	73. 4	76. 9	82. 4	74. 4	62. 6	90. 0
College:						
Number.....	104	33	30	17	11	13
Percent of total.....	33. 3	36. 3	58. 8	39. 5	10. 3	65. 0
Sanitarians with less than 4 years in present service						
Total number.....	124	45	30	14	29	6
8th grade:						
Number.....	124	45	30	14	29	6
Percent of total.....	100	100	100	100	100	100. 0
High school:						
Number.....	115	44	30	13	22	6
Percent of total.....	92. 7	97. 8	100	92. 9	75. 9	100. 0
College:						
Number.....	81	29	29	12	6	5
Percent of total.....	65. 3	64. 4	96. 7	85. 7	20. 7	83. 3

¹ Some of these had been to college, but did not graduate.

figures follow the social trends of past generations, when the education of many boys ended with grade school. Later, high school was the accepted stopping point. In the Maryland study, the findings were much the same, but employment of college graduates for this work began in Maryland a little earlier than in Pennsylvania.

The educational breakdown for the different agencies appears in table 2. Three-fourths of the group had finished high school; Philadelphia and private industry made the best showing. One-third graduated from college, Philadelphia and private industry again leading, with local workers far in the rear.

If we look at sanitarians employed only in the last 4 years, a different picture appears. Educational standards went up. Eleven-twelfths of the group had finished high school, and two-thirds, college. This is an indication of what happens today. These Pennsylvania figures in turn are higher than those in the 1954 study.

The major undergraduate courses taken are shown in table 3. Three-fourths (78 percent) followed courses in the biological sciences. Pittsburgh and private industry had a predilection for agricultural graduates, who were still more popular in Maryland.

The current in sanitation today runs strongly

Table 3. Major undergraduate fields for sanitarians with degrees in Pennsylvania, 1956

College major	Total	State	Philadel- phia	Pitts- burgh	Local	Private industry
Biology.....	34	16	13	2	0	3
Chemistry.....	10	3	2	3	0	2
Bacteriology.....	9	5	3	1	0	0
Agriculture or dairy science.....	17	2	1	6	2	6
Sanitary science.....	5	1	4	0	0	0
Veterinary medicine.....	8	2	2	0	4	0
Education.....	2	2	0	0	0	0
Mathematics.....	2	0	1	0	1	0
English, philosophy, psychology, history.....	9	2	3	2	2	0
Government, sociology.....	3	0	1	1	1	0
Other subjects.....	3	1	0	1	1	0
Not stated.....	4	1	0	1	0	2
Total.....	104	33	30	17	11	13

Table 4. Relationship of salary and educational level attained by Pennsylvania sanitarians, 1956

Salary group	Second college degree	First col- lege degree	High school graduate	Some high school	8th grade school or less	Total
\$2,499 or less.....	0	0	16	7	6	29
\$2,500-\$2,999.....	0	1	4	0	2	7
\$3,000-\$3,499.....	0	0	3	2	5	10
\$3,500-\$3,999.....	1	34	42	24	11	112
\$4,000-\$4,499.....	6	7	34	12	10	69
\$4,500-\$4,999.....	5	16	11	1	0	33
\$5,000-\$5,499.....	1	7	4	1	0	13
\$5,500-\$5,999.....	0	2	3	0	0	5
\$6,000-\$6,499.....	3	0	2	1	0	6
\$6,500-\$6,999.....	1	1	1	0	0	3
\$7,000-\$7,499.....	1	0	0	0	0	1
\$7,500-\$7,999.....	0	1	0	0	0	1
\$8,000 or more.....	6	5	2	0	0	13
Not stated.....	1	5	3	0	0	¹ 10
Total.....	25	79	125	48	34	312

¹ Educational level not stated for 1 person.

NOTE: Boldface numbers represent the salary group near which the median number falls.

in favor of the biology major. In 1954 the authors asked if anyone really knew whether this was well founded. Today we are emphasizing the importance of the social sciences. Will this be reflected in new requirements?

Table 4 shows that, by and large, educational background is reflected in the paycheck. Differences would probably be greater if it were not that those with less education have been longer on the job, and experience and native ability are valued as well as schooling.

Among the different agencies, local posts tend to pay less than State positions, and private industry appears to pay more than government. It is only fair to say that salaries, especially for State positions, have risen markedly since 1956.

Service and Training

In table 5, we note that more than a third of the sanitarians came to their present employers less than 3 years before this study. The proportion was largest in Philadelphia and in the State and was fairly even in the others. Philadelphia had only two who had been there more than 19 years.

The period of "service with present employer" is usually the same as "total service in sanitation." Sanitarians do some moving among jobs, but not a great deal.

A course of field training in basic sanitation of from 9 to 12 weeks is considered a standard in the preparation of sanitarians, much like the academic year of public health nursing. Those

Table 5. Length of service of Pennsylvania sanitarians with present employer, 1956

Years of service	Total	State	Philadelphia	Pittsburgh	Local	Private industry
Total number of sanitarians	312	91	51	43	107	20
Less than 3	113	44	30	11	23	5
3-4	28	6	1	4	13	4
5-9	54	14	7	10	19	4
10-14	36	6	6	8	15	1
15-19	40	15	5	4	15	1
20-24	21	2	2	5	11	1
25-34	15	2	0	1	9	3
35 or more	1	0	0	0	1	0
Not stated	4	2	0	0	1	1

Table 6. Pennsylvania sanitarians having had a course in basic sanitation, 1956

Training and year of training	Total	State	Philadelphia	Pittsburgh	Local	Private industry
Total number of sanitarians	312	91	51	43	107	20
Basic training						
MPH or BS in public health	17	0	14	2	1	0
9-12 week course	159	76	28	29	24	2
No basic course	136	15	9	12	82	18
Percent with training	54.6	83.5	66.7	72.1	23.4	15
Attendance at a short course						
1953	87	31	16	17	17	6
1954	102	29	34	19	13	7
1955	118	39	36	22	14	7
Number with no course	105	13	3	8	70	11
Percent with no course	33.7	14.3	5.9	18.6	65.4	55

with a master's or bachelor's degree in public health do not need this basic course, but the rest do. Table 6 shows a substantial need for such a course, particularly in the local and industrial groups.

Everyone needs the information and the stimulation of a short course in his field, yet only 87 of the 312 attended even one short course in 1953, 102 in 1954, and 118 in 1955. Philadelphia made the best showing of any of the agencies. But some workers in each category, as table 6 shows, attended not one short course in these 3 years. That is withering on the vine indeed. Attendance was especially low among the sanitarians in the smaller local health departments.

It is evident that the local sanitarians are a large body of health workers, usually insufficiently trained, with less formal education, and paid lower salaries than their associates in State or private industry jobs. However, these local people are natural aides for overloaded State

sanitarians. A State sanitarian in close touch with all local workers in his area can help and be helped by such association. It is clear that training for local sanitarians is a sound and necessary investment.

The sanitarians of private industry, barely touched in this study, warrant further coverage in the future.

Conclusion

The figures presented here should be studied by all of us for what they suggest, as a basis for planning and cooperation.

A similar study in other States would prove valuable.

REFERENCE

- (1) O'Brien, H. R., and Neill, A. H.: A pilot survey of sanitarians and their background. *Pub. Health Rep.* 70: 1222-1228, December 1955.

Heart-Sound Recording of Chicago School Children

The heart sounds of 40,000 public elementary school children in Chicago are being recorded in a new study launched on April 20, 1959. The study is being sponsored by an interagency committee. Ultrasensitive tape recording equipment, developed under Chicago Heart Association leadership, is being used; the heart sounds are being recorded on the tape for subsequent analysis. The Public Health Service is providing technical assistance and support.

The objective is to test this mass screening method as a rapid and practical means of finding individuals with abnormal heart sounds. The heart-sound recorder is believed to be as effective as the stethoscope.

In the study, which is scheduled to last about 18 months, at least two cardiologists will listen to all heart-sound recordings, and the findings of each specialist will be checked against the other. Parents of children who need further study will be notified, and secondary screening by physician examination will be performed.

Schools selected represent a cross section of the city's varied population groups. Guiding the project with the Service is a committee of representatives from the following Chicago groups and institutions: the Board of Health, the Board of Education, the Medical Society, the Heart Association, and local universities. A physician from the Chicago Heart Association is serving as project coordinator.

Signs

and

Symptoms

of trends in public health

"Understanding Aphasia," a 50-page booklet written by Martha L. Taylor, New York Institute of Physical Medicine and Rehabilitation, is designed to help families understand loss of speech and to acquaint them with speech rehabilitation.

" "

When the Chehalis Fluoridation League in Chehalis, Wash., offered \$1,000 reward in 1955 to anyone who could prove that fluorides in 1 ppm concentration had caused any ill effect to anyone anywhere, they were sued by Dr. F. B. Exner. His evidence was based on testimony of a man and wife who had severe dental fluorosis and who had lived in areas where the water supply was presumed to be less than 1 ppm in the public water supply.

Testimony revealed that the dental enamel of this couple had developed prior to the first studies of fluoride levels in water supplies, and that the water used by these people when they were children must have been in excess of 2 ppm. Dr. Exner lost his case and his appeal.

" "

Many members of insured medical plans waste benefits because they are inadequately informed and without guidance, reports the Columbia University School of Public Health and Administrative Medicine.

" "

Sterilizing male mosquitoes by irradiation with cobalt-60 has proved an effective means of reducing the population of malaria-carrying insects, report entomologists from the U.S. Department of Agriculture.

A 389-page study of the Windsor (Canada) medical services has been published by Harvard University Press. The book, "Comprehensive Medical Services Under Voluntary Health Insurance," was written by Benjamin J. Darsky, Dr. Nathan Sinai, and Dr. Solomon J. Axelrod, all with the Bureau of Public Health Economics, University of Michigan School of Public Health.

" "

Phreatophytes (thirsty plants and trees) drink 25 million acre-feet of water annually, reported Dr. D. L. Klingman and F. L. Timmons before the December convention of the American Association for the Advancement of Science.

" "

The Community Services Committee, AFL-CIO, has sent several letters to its local community services committees on health matters. One said, apropos of the Murray-Green Award to Dr. Salk, "The best gift we can give Dr. Salk is the full use of his vaccine." It recommended joint union-management, local health department, and county medical society cooperation in a mass inoculation program on a plantwide basis and in other relevant activities.

Local community services committees were urged also to advance fluoridation.

Since professional workers are "underpaid, underpraised, and unheralded," the committee suggested that community chests allocate 1 percent of total funds raised annually for scholarships. Forums on health problems were suggested as well as further development of public health departments.

Deaths caused by measles during 1957 outnumbered deaths caused by poliomyelitis for the first time since 1944. There were 410 deaths from measles and 220 from poliomyelitis.

" "

The Food and Nutrition Board has approved for publication a report entitled, "Evaluation of Protein Nutrition with Emphasis on Amino Acids Proportionalities," which presents a comprehensive background for critical consideration of the addition of specific amino acids to cereal foods for improvement of protein quality.

A report of the board's Food Protection Committee, with reference to the 1958 amendment to the Federal Food, Drug, and Cosmetic Act, entitled "Food Packaging Materials—Their Composition and Uses," is also approved for publication.

" "

Admissions to schools of professional and practical nursing reached a new high in 1958, according to the National League for Nursing, New York. An estimated 46,600 students entered basic professional nursing schools, compared with 44,281 the preceding year. Some 20,000 began training for careers in practical nursing, compared with 16,710 the year before.

" "

A new booklet, "Your Future," is offered without charge by the Office of Mental Education and Information, Department of Mental Hygiene, Albany, N.Y. Its purpose is to stimulate constructive thinking about the later years.

" "

The automobile insurance industry has set up an Institute for Highway Safety with annual appropriations of \$1,000,000.

" "

The Connecticut Heart Association, in cooperation with the pharmaceutical industry, the retail druggists, and the medical profession, has made it possible for anyone who has had rheumatic fever to purchase penicillin at a discount to prevent recurrence. The price is \$15 per year. Ordinarily a yearly supply costs several times that amount.

publications

Directory of Local Health Units. *PHS Publication No. 118; Revised 1958; 75 pages; 30 cents.*

Formerly entitled "Directory of Full-Time Local Health Units," this publication lists the name of each health unit, health officer or administrative head, and headquarters location. Included for the first time are all local areas which State health officers considered organized to provide public health services, irrespective of whether the health officer serves full time or part time, and whether medical, nursing, and sanitation public health services are available at all times.

Part-time employment of a health officer or administrative head is indicated. In addition, the absence of medical, nursing, and sanitation personnel is shown.

The National Mental Health Program and the States. *PHS Publication No. 629; 1959; 13 pages; 10 cents.*

For organizations and individuals interested in community mental health activities, this pamphlet describes grant-supported programs of the National Institute of Mental Health, Public Health Service. It sketches their operation and tells how they affect the States. Mental health consultants and State mental health authorities are listed.

The Mentally Retarded Child at Home. *Children's Bureau Publication No. 374; 1959; by Laura L. Dittmann; 99 pages; 35 cents.*

This manual for parents, approaching the problem of retarded children from the standpoint of sequences of growth and development, stresses the ways in which these children are like other children.

Included are suggestions for toilet training, dressing, cleanliness and manners, discipline, speech, play, and group experiences for the young retarded child. The manual also lists toys and equipment for home

play and provides parents of young children with long-range guides to problems which may arise during the retarded child's school days and his adjustments in adolescence.

Aging. A review of research and training grants supported by the National Institutes of Health. *PHS Publication No. 652; 1958; by G. Halsey Hunt and Stanley R. Mohler; 50 pages; 35 cents.*

A summary of the extramural research and training activities in aging conducted by the National Institutes of Health, Public Health Service, this review describes each of the categorical programs of the seven institutes and the general program of the Division of General Medical Sciences.

It also lists laboratories throughout the United States where research in aging is being conducted.

Sewage Treatment Works Contract Awards, 1952-1957. *PHS Publication No. 633; 1958; by William H. Abbott and Lewis C. Hudson, Jr.; 93 pages; 50 cents.*

This publication summarizes data originally presented in annual reports of public sewage treatment plant construction for the years 1952 through 1957 (PHS Publications Nos. 291, 409, 453, 488, 549, and 608). New tabulations show contract awards for the 6 years, by population size groups, by contract size groups, by drainage basins, and by States. Lists of individual projects, by year and by State, appear in an appendix.

Scientific Translations. A guide to sources and services. *PHS Publication No. 514; Revised 1959; 19 pages; 15 cents.*

Foreign and domestic institutions maintaining files of translations and offering translating services are described briefly and their publications are noted.

Periodicals in complete or partial translation are listed with subscription information. Russian journals in cover-to-cover translation are arranged alphabetically by both English and Russian title.

Information about professional organizations for translators and selected references on various aspects of translating are included.

Poultry Ordinance. *PHS Publication No. 444, Supplement No. 1; 1958; 9 pages.*

This supplement contains recommended provisions on antemortem and postmortem inspection of poultry for wholesomeness, for use by interested States and municipalities in conjunction with other provisions of the ordinance published in 1955. The supplement also includes some revised and additional labeling requirements and definitions necessary in relation to the inspection provisions.

When You Adopt a Child. *Children's Bureau Folder No. 13; Revised 1958; 28 pages; single copies 15 cents, \$10 per 100.*

Counseling prospective adoptive parents to give up all idea of finding a child without help, the booklet answers questions they might ask. It also reviews the questions which will be asked by the caseworker. A new section offers advice on citizenship and birth certificate needs of the child adopted from abroad.

This section carries announcements of new publications prepared by the Public Health Service and of selected publications prepared with Federal support.

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The Public Health Service does not supply publications other than its own.

ECHOES from Public Health Reports

RIBOFLAVIN DEFICIENCY IN MAN (ARIBOFLAVINOSIS)¹

By W. H. SEBRELL, *Surgeon*, and R. E. BUTLER, *Passed Assistant Surgeon, United States Public Health Service*

Many of the early writers on pellagra (1) recognized that certain symptoms of the disease sometimes occurred without the skin lesions, and the term "pellagra sine pellagra" was introduced to designate these symptoms. In 1912 Stannus (2), in describing pellagra in Nyasaland, particularly noted lesions in the angles of the mouth which he called "angular stomatitis." Similar lesions with various other symptoms have been described by numerous other observers. In 1928 Jenner Wright (3) in Sierra Leone described lesions at the mucocutaneous junction associated with nervous system lesions which were cured by cod liver oil and yeast. Lesions which appear to be similar in many respects have been seen by Fitzgerald (4) (1932) in an Assam prison; Moore (5) (1934) in school children in Nigeria; Landor and Pallister (6) (1935) in the prisons of Singapore and Johore, and Aykroyd and Krishnan (7) (1936) in school children in South India.

As early as 1918 Goldberger, Wheeler, and Sydenstricker (8) suggested that two different dietary factors may be involved in pellagra, and in 1925 Goldberger and Tanner (9), in their experiments with casein, noted that the patients developed a dry, glazed vermilion border of the lips, erosions at the angles of the mouth, reddening of the lips, and seborrhea about the nose. They diagnosed these lesions as pellagra sine pellagra. They also saw in some a pasty, caseous accumulation in the nasolabial folds which cleared up when dried yeast was added to the diet.

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Dr. W. H. Sebrell and Dr. R. E. Butler concluded that a diet low in riboflavin caused a condition known as "pellagra sine pellagra," since the condition disappeared with the administration of synthetic riboflavin. Dr. Sebrell and others later (*Public Health Reports* 56: 510-519, Mar. 14, 1941) specified a daily riboflavin requirement of an adult.

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